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A study of ultimate collapse strength in sagging of ship structures with side collision damage

Tak-Kee Lee, Chae Whan Rim*, Dae-Suk Han**, Byung Hyun Kim*, Jae-Myung Lee** and Ki Sup Kim****

* System Engineering Research Division, Korea Institute of Machinery & Materials

Daejeon, Korea
**Dept. of Naval Architecture & Ocean Engineering, Pusan National University
Busan, Korea
*** Maritime and Ocean Engineering Research Institute, KORDI
Daejeon, Korea

ABSTRACT

Ships in bad weather condition are likely to be subjected to accidental loads such as collision and grounding. Once she has damage on the hull, her ultimate strength will be reduced. This paper is to investigate the effect of the damage on ultimate strength of ship structure by using a series of collapse tests.

For the experiment, 720mm×720mm in section and 900mm in length of five box-girder models with stiffeners were prepared. Of the five, one has no damage and four have an ellipse shaped damage which represents the shape of bulbous bow of colliding ship. The damage size is different between models. Among the damaged models, the damages of 3 of them were made by cutting the plate and one by pressing to represent collision damage.

Experiments were carried out under pure bending load and load-deflection curves and ultimate bending moment were recorded. The ultimate strength was also calculated using LS-DYNA and compared with the experiment results.

The ultimate strength is reduced as the damage size increase, as expected. The largest damage one has the damage size of 30% of depth and its ultimate strength is reduced by 19%. The pressed one has higher ultimate strength than cut one. This might be due to the fact that the plate around the pressed damage area contributes to the ultimate strength, whereas the cut one has no plate to contribute.

KEY WORDS: Collision damage, ship structure, ultimate strength, pure bending load, box-girder model, collapse test

INTRODUCTION

Recently, the International Maritime Organization (IMO) and the International Association of Classification Society (IACS) are making a standard and regulation of ships considering the ultimate strength of plate and stiffened plate in ship structural design. The final goal of Goal Based Standards (GBS) prepared by IMO is the safe of ship during her life. To achieve the safety, all possible means should be used in every stage of ship life including design, building, operation and maintenance. In the design stage, the Common Structural Rules (CSR) for tanker and bulk carrier is a good example, in which ship structural designer must check the ultimate strength of plating under various loading conditions.

On the other hand, the longitudinal strength of hull girder which is composed of plate and stiffeners is the most important factor for sustaining the structural integrity of ship. If a ship with an accidental damage has some safety margin for the longitudinal strength, she may have a hope for survive for a while (its period depends on magnitude of safety margin). To have large safety margin is not advisable due to the efficiency of structural strength, the production costs, the operational costs, etc. So designer should have very dependable information on the ultimate strength of hull girder. This is main reason that the ultimate longitudinal strength becomes important concerns recently.

A few experimental studies on the ultimate longitudinal strength by using a large scale model have been done. Dow (1991) performed the ultimate strength test using a 1/3 scaled model of frigate naval ship under sagging condition. The total length including test jig reached 18 meters. The dimension of cross-section was 4.0m (breadth) × 2.8m (depth). In U.S.A., another large test of 6 point bending was carried out (Daniel et al, 2000). Its size was 1.5m × 1.1m in section and 4.6m (only specimen) in length simulating uni-directional stiffened double hull of three cargo holds. In China, a large model test by using hull girder structure of a large naval ship was conducted to obtain data related to the load carrying capacity (Qi et al, 2005). Dimensions of the model including five transverse bulkheads are about 6m in length, 0.8m in breadth (max. 1.4m; upper deck only) and 0.53m in depth. These experimental studies have provided a very meaningful data for the verification of related assessment tools.

The effect of accidental damage on ultimate strength of ship structure is also one of concerns. Ships in bad sea and weather condition are likely to be subjected to accidental loads such as collision and grounding. Once she has damage on the hull, her ultimate strength will be reduced. This paper is to investigate the effect of damage on ultimate strength by using a series of collapse tests. Experiments were carried out under pure bending load and an applied load and displacements on bottom plating were recorded.