ULTIMATE STRENGTH RESEARCH ON RIVER-SEA-GOING SHIP WITH LARGE HATCH OPENING

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ABSTRACT

The river-sea-going ship is often designed to be wide and flat due to the limitation of channel depth. Long and wide hatch opening is usually required in order to improve the efficiency of loading and unloading. There are enormous challenges on structural strength for such river-sea-going ship. In this paper, model test and nonlinear finite element analyses are combined together to research its progressive collapse behaviour under combined vertical bending and torsional moments. Test model is fundamentally designed in accordance with distorted similarity theory in which plate thickness is considered as an independent dimension. Then, the similarity of slenderness ratio which is principal parameters affecting the ultimate strength of plating and stiffened plate subjected to compressive load is considered to determine the spacing and size of the stiffener. Finally, the ultimate strength of actual ship is deduced through that of test model and compared with that obtained by nonlinear finite element analysis.

KEY WORDS: Ultimate strength; model test; distorted similarity theory; river-sea-going ship; combined vertical bending and torsional moments; nonlinear finite element analysis.

INTRODUCTION

It is said that more than 40% economic output generated in the valley of Yangtze River and transportation volume in Yangtze River accounts for 80% of total inland transportation in China (Changjiang River Administration of Affairs, 2012). Recently, with the rapid economic development in the valley of Yangtze River, river-sea-going ship is demanded by shipping market. Shipping line shall be from Ningbo Beilun Port transporting iron ore, coal, cement and clinker to Wuhan industrial port. River-sea-going ship directly transports from sea to river, reducing the cargo transfer process, shortening the voyage time so that the shipping costs can be decreased. So, it has a competitive advantage due to its economic and social benefits.

Ships with larger capacity have merit in the current shipping market because the cost of fuel oil account for more than half of the total cost. Investigation results indicate that ship tonnage larger than 10,000t has the possibility to make profit. However, the depth and draft for the ship navigating in Yangtze River are constrained due to the present dock status, limitation of channel depth and constraints of bridge clearance height. And the ship length is also restricted by the demand of flexible maneuverability. The only possibility is to increase ship breadth in order to have larger capacity for cargoes. The hatch opening is always long and wide due to the requirement of high efficiency on loading and unloading cargoes which may lead to torsion problem when the loading situation is unsymmetry or the ship is subjected oblique wave. So, there is challenge on structural design for river-sea-going ship having large ratio of breadth and depth (B/D) and large hatch opening.

In the present research, model test and numerical calculation are adopted to investigate the ultimate strength of river-sea-going ship under combined vertical bending and torsional moments. Firstly, the similarity criterion and similarity parameter are determined in accordance with distorted similarity theory. Test model is so designed that it can reflect the characteristics of both elastic and buckling/plastic collapse behaviour. Successively, the complex condition combining vertical bending moment and torsional moment is decided. Model test is conducted under such condition to research its progressive collapse behaviour. Then, numerical simulation is also performed using nonlinear finite element software package (ABAQUS) considering both geometry nonlinearity and material nonlinearity. The results obtained by ABAQUS are compared with test results. Finally, the ultimate strength of objective ship can be deduced through that of test model. And it is compared with numerical result performed on actual ship model.

TEST MODEL AND EXPERIMENTAL METHOD

In this chapter, the principle dimensions and structural characteristics of the objective ship are concisely introduced firstly. The design of test model is described successively. Finally, the experimental methods are discussed.

Objective Ship and Test Model

PRINCIPLE DIMENSIONS AND STRUCTURAL CHARACTERISTICS OF THE OBJECTIVE SHIP. A 12000t river-sea-going ship is considered in the present paper of which principle dimensions and structural parameters are given in Table 1. There are two cargo holds and the ratio of length of hatch