Simplified Analysis Tool for Ship-Ship Collision

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ABSTRACT
The purpose of this paper is to develop a simplified ship collision analysis tool in order to estimate the structural damage and energy absorption of both striking and struck ships as well as prediction of rupture of cargo oil tanks of struck tankers. The present tool calculates external and internal dynamics independently. The 2-dimensional horizontal motions of both ships are taken into account. Structural deformation for both the striking and the struck ship is evaluated independently using rigid-plastic simplified analysis procedure. The developed tool was applied to the collision scenario where a VLCC in ballast condition collides perpendicularly with the mid part of another D/H VLCC in fully loaded condition. The results obtained from the present tool are compared with those obtained by large scale FEA, and fairy good agreements are achieved. The applicability, limitation and future enhancement of the present tool are discussed in detail.

KEY WORDS: ship collision; simplified analysis method; rigid plastic analyses; bulbous bow.

INTRODUCTION
In order to reduce the risk of oil spill from struck oil tankers, the buffer bulbous bow, which absorbs the kinetic energy of striking ship before penetrating the inner hull of struck ship, was proposed (Kitamura, 2000). In order to evaluate the effectiveness of the buffer bow probabilistic approach such as risk and reliability analysis is needed. In order to perform such analyses rapid and simplified evaluation method for ship collision analysis are necessary. In most of previous researchs on damage caused by collisions the bows are treated as rigid, exceptions are Lützen et al, 2000 and Wierzbicki & Simonsen 1996. In evaluating the buffer bow, however, it is necessary to take into account deformation of the struck ship side as well as that of the striking ship bow.

In the present study a simplified ship collision analysis tool (SSACT) is developed considering the deformation of both the striking and struck ship. The accuracy of the present tool was investigated by comparing the results obtained by the present tool with that by FEA.

SIMPLIFIED SHIP COLLISION ANALYSIS TOOL (SSCAT)
Ship collision analysis can be divided into global ship motion analysis (external dynamics) and structural deformation analysis (internal dynamics). In order to rapidly and simply carry out collision analysis external dynamics and internal dynamics are calculated independently in the present tool.

External Dynamics
External dynamics is calculated using the method proposed by Pedersen & Zhang (1998). The method treats three degrees of freedom (surge, sway and yaw motions) of both a striking and a struck ship. The pressure effect of surrounding sea water corresponding to the above three ship motions is taken into account as a virtual added mass, and added mass coefficients used are based on the studies by Minorsky (1959) and Motora et al (1969). By solving force and moment equilibriums as well as conservation of momentum and energy, the energy which should be absorbed by structural deformation and friction (what we call “Lost Kinetic Energy (LKE)”) during the ship collision is represented by closed formula. This method is applicable not only for perpendicular collisions but also for oblique collisions.

LKE is represented as:

\[
LKE = E_\eta + E_\xi
\]  

where, \( E_\eta \) and \( E_\xi \) are LKE in \( \eta \) and the \( \xi \) direction. A ratio \( \mu \) is introduced between the impulses in the \( \eta \) and the \( \xi \) direction. \( E_\eta \) and