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Marine Accident Cause Investigation using M&S System

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고도 정밀 M&S 시스템을 이용한 해난사고 원인규명

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Abstract : *It is necessary to develop highly sophisticated Modeling & Simulation (M&S) system for the scientific investigation of marine accident causes and for the systematic reproduction of accidental damage procedure. To ensure an accurate and reasonable prediction of marine accidental causes, such as collision, grounding and flooding, full-scale ship M&S simulations would be the best approach using hydrocode, such as LS-DYNA code, with its Fluid-Structure Interaction (FSI) analysis technique. The objectivity of this paper is to present three full-scale ship collision, grounding and flooding simulation results of marine accidents, and to show the possibility of the scientific investigation of marine accident causes using highly sophisticated M&S system.*

Key words : *Investigation of marine accident cause, Highly sophisticated Modeling & Simulation system, LS-DYNA code, Fluid-Structure Interaction analysis technique, full-scale ship M&S simulation*

1. Introduction

Investigation of marine accident causes usually depends on the judgments of maritime experts, based on the statements of the concerned persons in the case where there is no navigation equipment, such as AIS and VDR. Scientific verification also has a limitation in the case of their conflicting statements. It is necessary to develop a highly sophisticated Modeling & Simulation (M&S) system for the scientific investigation of marine accident causes and for the systematic reproduction of what happens in marine accidents.

To ensure an accurate and reasonable prediction of marine accident causes, such as collision, grounding and flooding, full-scale ship M&S simulations would be the best approach using hydrocode, such as LS-DYNA (LSTC, 2011), with its Fluid-Structure Interaction (FSI) analysis technique. Several interaction effects in the seawater are conceptualized in this highly sophisticated M&S system. Fracture criteria have to be suitably applied to the ship structural damage considering strain rate effect.

2. FSI analysis and damage mechanics

FSI problems are conveniently simulated by moving the mesh algorithm and overlap capability of the grid to structure mesh using the Multi-Material Arbitrary Lagrangian Eulerian(MMALE) formulation and the Euler - Lagrange coupling algorithm of LS-DYNA code, as shown in Fig. 1. Volume Of Fluid(VOF) method is adopted for solving a broad range of nonlinear free surface problems (Aquelet et al., 2006).

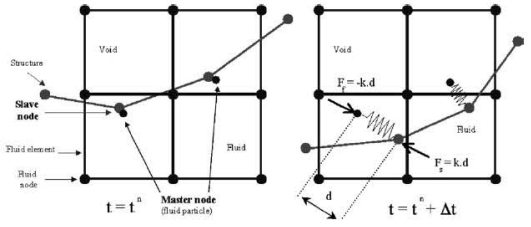

Fig. 1 Sketch of penalty coupling algorithm

1:5 scale grounding test results of NSWC (Rodd & Sikora, 1995) are usually used for the verification of F.E. simulation capacity and fracture criteria. One of grounding

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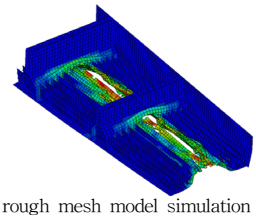
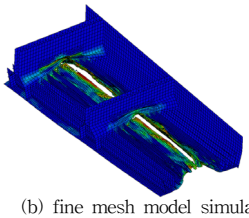
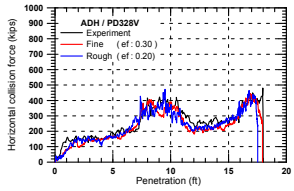
test models, ADH/ PD328V, was simulated using rough and fine mesh models with failure strains from 0.20 to 0.35, as shown in Fig. 2 with material properties of ASTM 569. It was found that failure strain 0.3 and 0.2 were suitable for the fine and rough meshes with ratio 12.5 and 25.0 of finite element size to thickness, respectively (Lee, 2007).



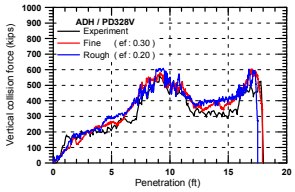
(a) rough mesh model simulation



(b) fine mesh model simulation



(c) horizontal force response



(d) vertical force response

Fig. 2 Grounding test simulation of ADH/PD328V model

3. M&S simulation of marine accidents

Four full-scale collision and one flooding simulations are presented; investigations of two ship-to-ship collision accidents between fishing boat and bulk carrier, and pelagic fishing ship and bulk carrier, collision safety assessment of high-speed passenger ship with underwater floating object (whale), collision damage assessment of bulk carrier with floating or submerged object, and investigation of flooding accident of ship, as shown in Figs, 3~7, respectively.

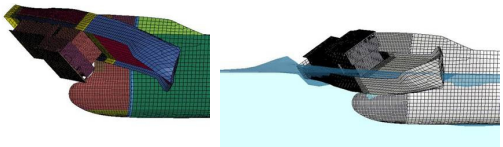


Fig. 3 Full-scale collision simulation between fishing boat and bulk carrier

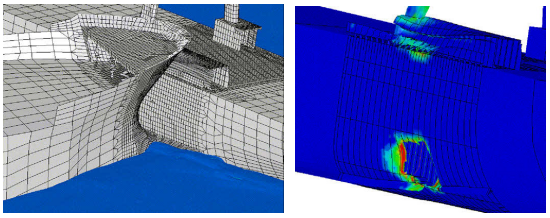


Fig. 4 Full-scale collision simulation of pelagic fishing ship and bulk carrier

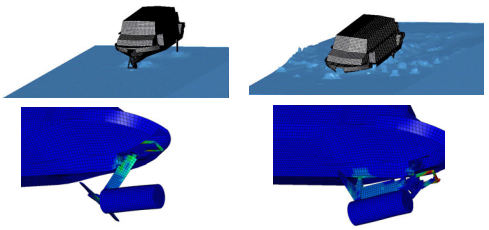


Fig. 5 Collision safety assessment of high-speed passenger with whale

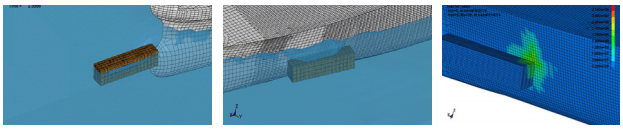


Fig. 6 Collision damage assessment of bulk carrier with floating or submerged object

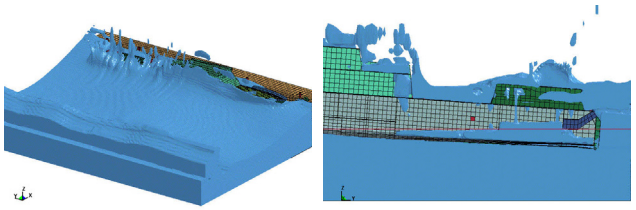


Fig. 7 Full-scale flooding simulation of ship

4. Conclusion

Through full-scale ship M&S simulations of marine accidents using FSI analysis technique, the usefulness of highly sophisticated M&S system was reconfirmed for the scientific investigation of marine accidents and for the systematic reproduction of accidental damage procedure. Ship maneuvering simulation system should be joined for comprehensive investigations.

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