Numerical Study on the Slamming Impact of Wedge Shaped Obstacles considering Fluid-Structure Interaction (FSI)

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ABSTRACT
The purpose of the present study is to investigate slamming impact of ships as well as to investigate applicability of nonlinear explicit finite element code LS-DYNA to simulations of slamming impact of ships. In this study a series of two-dimensional slamming impact simulations were carried out with using LS-DYNA where sea water is modeled by Euler solid elements and wedge is modeled by Lagrange shell elements. Fluid structure interaction (FSI) is taken into account by coupling fluid analysis and structural analysis in each time step of time domain simulations. In order to validate numerical simulation, water entry of rigid wedge is simulated, and pressure distribution and slamming impact estimated by simulations are compared with those by conventional Wagner theory.

KEY WORDS: Slamming; FSI; Water impact;

INTRODUCTION
Impact of slamming is one of important issues for structural safety of ships. More specifically it is important to accurately estimate global/local structural response of ships against slamming impact under bottom of ship bow. It was thought to be time-consuming and not practical to carry out water impact analysis with coupling both fluid and structure. However as a considerable development of computer technology as well as computational numerical methods, water impact analysis with coupling both fluid and structure is becoming more and more practical in ship building design.

Luo et al (2011) carried out water impact analysis of small-scale rigid wedge using LS-DYNA and found its practical applicability. Nakashima et al (2011) also carried out similar analysis for elastic-wedge using LS-DYNA and found its applicability not only to rigid wedge but also to elastic wedge where fluid structure interaction (FSI) is taken into account. However these previous studies are mainly for water impact of small-scale structures, which is much smaller than actual large ships. It is noted that these previous studies are very important to validate accuracy and applicability of numerical methods as well as obtain numerical techniques and tips.

On the other hand in order to investigate fluid structure interaction in slamming impact it is necessary to model structure as elastic. However it is questionable to directly reflect results of water impact of small scale structures to actual large scale structures although law of similarity is satisfied. In small scale analysis, in order to equivalence bending rigidity according to law of similarity, very thin shell thickness needs to be used at the bottom shell plating of the structures. In case of static/quasi-static analysis these method can be applied. However in case of dynamic coupling analysis situation might be different. In these cases natural frequency and dynamic structural response of these shell plate might be quite different from those in actual ships. Span of longitudinal stiffeners might also be different from actual ships. Moreover, while varying bottom plate thickness according to scaling low, density of steel and water cannot be changed in order to correctly simulate propagation of stress wave and acoustic wave respectively in dynamic analysis. Consequently large deflection might be obtained in numerical results which might not be observed in actual ship impacts.