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Comparative Study on Time-Domain Analysis of Ship Motions and Structural Loads in Waves

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ABSTRACT

A comparative study has been performed by comparing the ship motions and wave loads computed by different ship motion programs. Recently, a time-domain ship motion program, WISH has been developed under the support of five ship building companies and Korean Register. WISH is based on B-spline Rankine panel method which is capable to solve linear and nonlinear seakeeping performance including hull-girder structural loads. In the present paper, the linear and nonlinear motions and loads obtained using WISH are compared with those of commercial code and experimental data for LNG carrier, Hanjin containership, and S175 hull, showing a good agreement.

KEY WORDS: Seakeeping analysis; Ship Motion; Time-domain analysis; Rankine panel method; Nonlinear Motions

INTRODUCTION

The analysis of motion responses and structural loads is an essential element for ship design. Thanks to the recent trend of lengthening ship size, the demand of nonlinear analysis for the prediction of ship motions and global hull-gird loads is high. Some programs, distributed mostly by ship classification societies, show the capability of nonlinear analysis, and it seem that the application of such programs will be getting more popular. These programs are mostly based on Rankine panel method which is very practical and efficient to extend nonlinear analysis. Dawson (1977) gave an inspiration to many researchers to apply the Rankine panel method for wave resistance problem, and later Sclavounos and Nakos (1988) provided an important theoretical foundation by conducting a thorough stability analysis for the Rankine panel method. Nakos (1990) developed it to a frequency-domain solver on unsteady ship motion problem. Lin and Yue (1990) and Kring (1994) then extended to time-domain problems, and later extended it to nonlinear problems (Lin et al., 1994; Kring et al., 1996). These programs were developed to SWAN2 and LAMP2, which have world-wide fame for nonlinear ship motion analysis in time domain, and later developed to WASIM (DNV) and NLOAD3D (ABS), respectively.

There are some comparative studies on nonlinear time-domain programs (Watanabe and Guedes Soares, 1999; 14th ISSC, 2000), however, previous comparative studies were concentrated on nonlinear strip methods. Recently, Singh and Sen (2007a, 2007b) did comparative study by considering body nonlinearity level based on 3D Greed function method. However, a thorough comparative study on Rankine panel method, particularly for time-domain analysis, is not introduced yet.

During last a couple of years, five largest Korean shipbuilding companies and Korean Register have supported the development of WISH (a computer program for nonlinear Wave-Induced loads and SHip motion analysis). WISH is based on Rankine panel method in time domain, and it was extended to weakly-nonlinear analysis (Kim et al., 2008). In the present paper, a comparative study for linear and nonlinear problems by time-domain ship motion programs based on Rankine panel method is introduced. These studies include the comparison between experimental data and the computational results of WASIM(or SWAN), NLOAD3D and WISH. The present paper summarizes some results of the comparative studies. It should be noted that this paper does not aim to show which program is better or to compare the capabilities of the programs to be considered. The paper intends to introduce important findings during the comparative study and raise some critical issues in the application for ship design.

DEVELOPMENT OF WISH PROGRAM

Equation of Motion

Let's consider a ship advancing with arbitrary forward speed, U . The ship is freely floating, so that it experiences motion responses in waves. Let's define the ship motion in mean-body coordinate system such as Fig.1. β is the incoming wave heading angle. If ship is a rigid-body, it has 6 degrees of freedom. Under the linear assumption, the equation of motion is derived as follows:

$$\left[M\right]\left\{\ddot{\xi}_i\right\}+\left[C\right]\left\{\ddot{\xi}_i\right\}=\left\{F_{F.K.}+F_{H.D.}\right\} \quad i=1,2,\cdots,6 \qquad (1)$$

where, $[M]$, $[C]$ are the mass and restoring coefficient, respectively,