International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 15, No. 3, September 2005, pp. 210–214

Rationalization of Design of Side Structure of Ice-strengthened Tankers

Ge Wang, Roger Basu, Dipak Chavda and Shewen Liu
Technology Group, American Bureau of Shipping, Houston, Texas, USA

Myong-Sup Lee
Technology & Business Development, ABS Pacific, Busan, Korea

Yong-Suk Suh and Yoo-Jhung Han
Marine Research Institute, Samsung Heavy Industry, Geoje, Gyeongnam-do, Korea

The industry demand for ice-classed tankers is rapidly increasing as a result of the growing exports of oil from Russia. There has been a trend toward allowing for alternative designs using direct calculation approaches. However, no complete procedure is available. This paper presents a procedure for designing ice-strengthened structures of tankers using direct calculation approaches. It addresses the main issues, including ice load definition, material modeling, structural modeling and acceptance criteria. The paper summarizes a recent joint ABS-SHI project that will become the basis of the future, refined design practice.

INTRODUCTION

Due to the increasing Russian oil exports from the Port of Primorsk and Sakhalin, the number of new tankers being ordered with ice strengthening is steadily growing. Russia is the second-largest crude oil exporter after Saudi Arabia, and as the country's port and pipeline infrastructure is expanded, it may export around 1.5 million barrels per day in 2010, compared to just over 500,000 barrels per day in 2002.

In addition, because traffic in the Baltic Sea is also growing, the environmental suitability of tankers traveling in the coastal waters of Finland, Sweden and other Baltic nations is an issue of public concern.

Considering these factors and the recent harsh ice conditions in the Baltic Sea and Gulf of Finland, tanker owners are intending to build vessels to ice classes. The Ice Class fleet is expected to grow by 9% in 2004, 12% in 2005 and 33% in 2006, according to Clarkson Research.

The vessels traveling in the North Baltic are required to be in compliance with the Finnish-Swedish Ice Class Rules (FMA, 2002), abbreviated as FSICR below. The majority of the new ice-strengthened tankers are built to the FSICR, which have been widely adopted by all major classification societies, such as the American Bureau of Shipping (ABS, 2005a). The Rules require that longitudinal frame spacing be less than 450 mm and brackets be used to connect side longitudinals to webs.

In response to the recent needs of commercial producibility, the Finnish Maritime Administration (FMA) accepts alternative designs if they are shown to be equivalent based on direct calculation (FMA, 2003). Commercial tankers typically have longitudinal spacing of about 800 mm, wider than the FSICR-required ice-strengthening frame spacing. Installation of the FSICR-required brackets to connect side longitudinals to webs does pose challenges to commercial producibility. Thus, FMA released *Tentative Guidelines for Application of Direct Calculation Methods for Longitudinally Framed Hull Structure* (FMA, 2003) for larger commercial vessels. These guidelines were included in the latest FMA general guideline on application of the FSICR (FMA, 2004). In April 2004, following the FMA guidelines, ABS published *Guidance Notes on Nonlinear FEM for Side Structures Subject to Ice Loads* (ABS, 2004), providing detailed procedures for conducting direct calculations by nonlinear FEM. These ABS guidance notes have been gaining popularity and recognition.

The FMA guidelines still use prescriptive formulas to calculate the required side shell plate thickness, just as the FSICR do. The industry widely holds that there is a strength imbalance between the side shell and side longitudinals, with the side shell having a higher reserve strength compared to the side longitudinals. However, there is no established way to evaluate the safety reserves of the side shell against ice loads.

Recently, ABS and SHI have been developing a direct calculation procedure to determine a rational side shell thickness under ice loads. The emphasis is placed on achieving a more balanced design of the entire side structures. This paper gives an overview of this design procedure for the side structures of ice-strengthened tankers, highlighting the procedure that is incorporated into the ABS *Guidance Notes on Ice Class* (ABS, 2005b). This paper provides an example to demonstrate the procedure.

DESIGN PROCEDURE

The design procedure involves 4 steps for the alternative design of the side structure for tankers under ice loads. Table 1 lists the steps of the design sequence for side structures. The first step is to have a design complying with FSICR, which will be used as a baseline design for the alternative designs. The second step is to have an interim design following FMA guidelines (FMA, 2003, 2004) if the longitudinal spacing is wider than that required by FSICR. The third step is to use nonlinear FEM to have an alternative design for side longitudinals following FMA guidelines (FMA, 2003, 2004; ABS, 2004). The fourth and last step is to determine side shell thickness. In this last step, targeted by the main development of the latest ABS *Guidance Notes*, patch loads approximately corresponding to extreme ice loads are applied

Received February 20, 2005; revised manuscript received by the editors April 22, 2005. The original version (prior to the final revised manuscript) was presented at the 15th International Offshore and Polar Engineering Conference (ISOPE-2005), Seoul, June 19–24, 2005.

KEY WORDS: Ice load, side structure, permanent deformation, ice-strengthened tanker.