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Modeling of Brash Ice Channel and Tests with Model *CCGS Terry Fox*

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When an ice-going vessel navigates in the Baltic Sea, it normally follows a channel that has been made by previous ships or icebreakers. The channel is filled with broken ice pieces and repeated traffic makes the size of the ice pieces smaller. The typical size of the broken ice pieces is less than 2 m (Mellor, 1980), and the upper part of the channel can be frozen forming a consolidated layer. This is called a brash ice channel. In the Baltic Sea, a large demand for ice-going vessels is expected because of the transport of oil and gas from Russia to Europe. In order to design or assess the overall performance of a vessel transiting brash ice, model tests are essential, and appropriate brash ice modeling techniques play an important role in the success of the model tests. This paper proposes a methodology for producing a brash ice channel in an ice tank for model tests. The targeted ice class was the Finnish-Swedish Ice Class Rules (FSICR, 2005) class 1B, with 46-mm-thick brash ice at model scale (1 m at full scale). The basic concept behind producing the brash ice channel was the dumping of pre-broken ice pieces along the tank. The effects of the size of the broken ice pieces and the number of layers were taken into account. The test results suggest that an appropriate modeling of brash ice resistance requires at least 2 layers of ice pieces.

NOMENCLATURE

D	Diameter of propeller (0.22 m)
F_D	Towed force
$J = \dfrac{V}{nD}$	Advance coefficient
$K_{FD} = \dfrac{F_D}{\rho n^2 D^4}$	Towed force coefficient
$K_{Q\_PORT} = \dfrac{Q_{PORT}}{\rho n^2 D^5}$	Shaft torque coefficient at port
$K_{T\_PORT} = \dfrac{T_{PORT}}{\rho n^2 D^4}$	Shaft thrust coefficient at port
T_{PORT}	Shaft thrust at port
$T_i,\ Q_i$	Thrust and torque in ice
$T_o,\ Q_o$	Thrust and torque in open water
Q_{PORT}	Shaft torque at port
V	Carriage speed
ρ	Density of fluid in which propeller operates

INTRODUCTION

The export of Russia's northern oil through the port of Primorsk on the Baltic Sea has been increasing, resulting in an increased demand for ice-class tankers for oil transportation. Examples are the 117,000dwt IA Super ice-class tanker *Stena Arctica*, built in 2006 for trading between Sweden and Russia, and a dozen large, ice-class tankers that operated in 2008, including her sister ship, *Stena Antarctica*. Any tanker that operates in the Baltic Sea must meet appropriate ice-class levels specified by the Finnish-Swedish Ice Class Rules (FSICR), which range from IA Super, IA, IB, to IC. The Class IA Super is designed for a ship that navigates the most difficult ice conditions in the Baltic Sea: 1.2-m-thick first-year ice. The FSICR also set the power requirement for a tanker navigating the brash ice channel. For example, the IA Super ice-class tankers should be able to pass through 1-m-thick brash ice with a consolidated top-layer channel at a speed of 5 knots. This study meets a recent demand for performance evaluation of ice-class tankers transiting brash ice by developing appropriate model test methodology.

Research on ship performance in brash ice has been carried out by Mellor (1980), Sandkvist (1981), Kitazawa and Ettema (1985), Ettema et al. (1998), Nortala-Hoikkanen (1999), and Hellmann et al. (2005). The FSICR (2005) provide a guideline for model tests in a brash ice channel. According to these rules, the thickness of a brash ice channel increases from the centre to the edge with the gradient of 2°. This is based on measurements from the Gulf of Bothnia, as shown in Fig. 1. Since it is difficult to produce the shape described in Fig. 1 in an ice model basin, the FSICR (2005) suggest the use of a constant thickness (H_{av}) that can be calculated by Eq. 1:

$$H_{av} = H_M + 14.0 \cdot 10^{-3} B \tag{1}$$

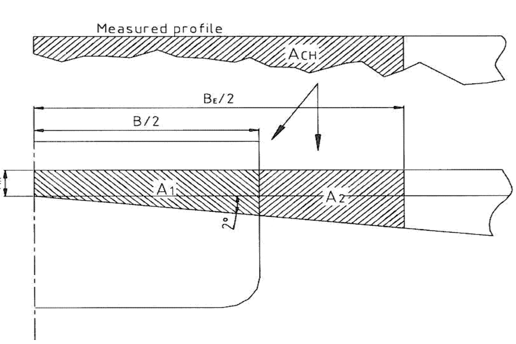

Fig. 1 Measured brash ice channel (from FSICR, 2005)

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