An Experimental Study for the Mechanical Properties of Model Ice Applying for the MOERI Ice Model Basin

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ABSTRACT

One of the tasks when evaluating the performances of ice class vessels and Arctic offshore structures in an ice model basin is to prepare a proper model ice which shows correct similitude with natural sea ice. Every ice model basin in the world has individually developed the ice modeling technique and methodology to assist their adaptation. The EG/AD/S model ice which is a diluted aqueous solution of ethylene glycol, aliphatic detergent and sugar, may provide for the correct scaling of mechanical properties of columnar sea ice. The MOERI(Maritime & Ocean Engineering Research Institute) ice model basin of Korea scheduled to open in 2009, adopts the EG/AD/S type model ice, with a collaboration of the IOT(Institute for Ocean Technology), Canada.

This study focuses on the evaluation of mechanical properties of EG/AD/S type model ice for possible use in the new MOERI ice model basin. Before completion of the new ice model basin, instead of using actual ice model basin, a cold room facility was used for making model ice growth and measuring its mechanical properties. The warm-up technique applied for the model ice growth seems to be most important factor to reduce ice strengths in this test. It was reported that the sugar component in the model ice solution may cause a difficult maintenance problem due to organic bacteria. Hence the influence of sugar component on the original EG/AD/S model ice was tested to check the possible removal of sugar from the original EG/AD/S solution.

KEY WORDS: Ice model basin; EG/AD/S model ice; Cold room; Flexural strength; Elastic modulus

INTRODUCTION

Recent dramatic change in energy prices and the global warming trend accelerate the development of Arctic/sub-Arctic regions and also enhance the activities in the Arctic seas. Especially, the exploration of natural resources and their transportation through the Northern Sea Route made it possible to reduce the operation cost and to derive new design concepts of ship and offshore structure.

Model ices are usually made of fresh water with various additives such as sodium chloride, urea and other chemical substances. Timco (1986) introduced a new type of model ice that was grown from an aqueous solution of three different dopants, ethylene glycol (EG), aliphatic detergent (AD), and sugar (S). Reported features of EG/AD/S ice are single-layered, fine-grained, and a columnar type. The scalability of EG/AD/S ice was superior to that of the urea model ice in all aspects, including improved scaling of strength, failure envelope for compression, strain modulus and fracture toughness. For the $E/\sigma_f$ ratio, EG/AD/S model ice gives a value between 1,500 and 2,500 for whole ranges of flexural strengths (20–100kPa).

Spencer and Timco (1990) introduced an improvement to the EG/AD/S ice, called CD(Correct Density)-EG/AD/S ice. The density of this model ice was reduced by trapping air bubbles in it. In addition, CD-EG/AD/S model ice had several advantages in comparing to EG/AD/S model ice, i.e., the improved visibility, the higher $E/\sigma_f$ ratio and the lower fracture toughness.

The first Korean ice model basin will be completed at the Maritime and Ocean Engineering Research Institute (MOERI) in 2009, to assess the ice performance and ice load estimation on ships and offshore