

## A Study on the Shearing Strength and Adhesive Strength of Sea Ice

*Hisao Matsushita and Toru Takawaki*

Mitsui Engineering and Shipbuilding Co. Ltd., Chiba, Japan

*Takahiro Takeuchi*

Shimizu Corporation, Tokyo, Japan

*Masafumi Sakai*

Taisei Corporation, Yokohama, Japan

*Takashi Terashima*

Pacific Consultants Co. Ltd., Tokyo, Japan

*Hideki Honda, Akifumi Nishihata and Hiroshi Saeki*

Hokkaido University, Sapporo, Japan

### Abstract

In designing an offshore structure in an ice-covered sea area, understanding the ice load exerted by sea ice is necessary.

To determine the adhesive and the shearing strengths of sea ice and their relation to the bending strength, we used the first-year ice at Notoro Lagoon. To define the stress distribution of the shearing strength of the test specimen, we used the finite element method elastic stress analysis. The adhesive strength test specimen kept outdoors separated at the attached surface, yielding an adhesive strength of 50 kPa. The shearing strength test specimen ruptured in bending. The shearing strength was found to be between 0.2 and 0.3 MPa.

**Keywords:** sea ice, shearing strength, adhesive strength, FEM analysis

### 1. Introduction

To calculate the precise ice load exerted on an offshore structure in an ice-covered sea area, clarification of various characteristics of strengths of sea ice is necessary. The characteristics of the compressive strength and the bending strength of sea ice (first-year ice) have been clarified by many researchers, including Matsushita et al<sup>1)</sup>.

In this study, we clarify the adhesive strength between blocks of sea ice and the shearing strength. These are important strength factors to calculate the strength of sea ice when fractures of pack ice adhere each other or a hummock around offshore structures (Figure 1). To calculate the ice load when level ice hits against a vertical wall structure, consideration needs to be given to the shearing strength in addition to the compressive strength (Figure 2). Therefore, using sea ice in Notoro Lagoon, we researched the adhesive and shearing strengths of sea ice left in the open air or kept frozen at  $-20\text{ }^{\circ}\text{C}$  for about a month to find the we determined the changes with time. Also, we used the finite element method (FEM) elastic stress analysis to find the stress distribution of test specimens and examined in detail the strength at the point of failure. From the results, we determined the changes in the adhesive strength with time and

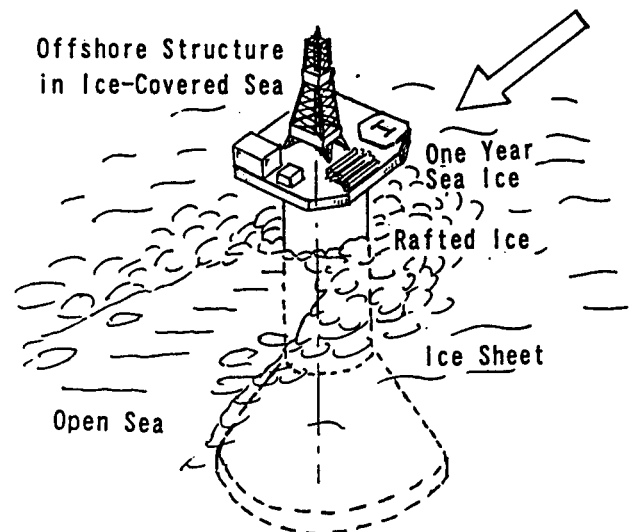
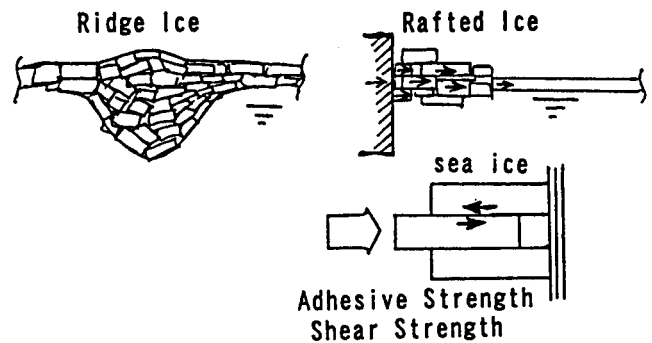


Figure 1 Conceptual view of offshore structure in ice-covered sea