Experimental Study on Vertical Ice Loads Acting on Pile Structures with a Circular Cross-Section

Takashi Terashima and Akifumi Nishihata
Pacific Consultants Co. Ltd., Sapporo, Japan
Hideki Honda
Hokkaido University, Sapporo, Japan
Kyoichi Narita
Shimada Construction Co. Ltd., Japan
Kunihiro Kawai
Nishimura-gumi Co. Ltd., Japan
Hiroshi Saeki
Hokkaido University, Japan

ABSTRACT

When ice sheets adfreeze to structures with a circular cross-section, vertical ice loads act on them as the water level changes due to the tides. The ice loads on structures grow greater with increased changes in water level. However, when the change in water level reaches a certain degree, the ice sheets fracture. The modes of failure are classified roughly as bending failure and adfreeze bond failure whereby the ice sheet is exfoliated from the surface of the structure. Furthermore, bending failure can be subdivided into two forms of cracking: radial cracking and circumferential cracking. We developed theoretical equations to estimate the vertical ice loads, which correspond to each mode of failure, and verified the equations through field experiments although only a limited number of experiments were performed in this research.

Keywords: mode of ice failure, vertical ice load, offshore pile structure with a circular cross-section.

1. FIELD EXPERIMENTS

1.1 Experimental method

In January, 1997, we made a full-scale experiments at Yobito fishing port on the shore of Lake Abashiri, which is unaffected by tides. Table 1 shows the cross-sectional parameters in four test cases. The procedure of the experiment is as follows.

<table>
<thead>
<tr>
<th>Table 1 Test cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test case</td>
</tr>
<tr>
<td>Test cases 1 &amp; 2</td>
</tr>
<tr>
<td>Test cases 3 &amp; 4</td>
</tr>
</tbody>
</table>

- a) We floated and set model piles 10 m from the quay so as not to be affected theoretically by the quay. This was done in early December before the water surface inside the fishing port freezes over.

- b) The port froze in mid December and the ice thickness was around 30 cm in early January. We pulled up piles vertically by a crane at a rate of 0.13 mm per second, which is close to the rate that tides change the water level (Figure 1). The uprooting force of piles was measured by a load cell installed between the crane and the pile. Also, the displacement of the ice sheet was measured every five seconds at four positions (the installation point of the pile, and at 2 m, 4 m and 6 m from the installation point) using four levels.

- c) The measurement continued until a flexural failure or an adfreeze bond failure between the ice sheet and the pile occurred and we could pull out the pile completely. In addition to visual observation, the sound of flexural failure of the ice sheet and its cracking patterns were recorded by video.

- d) Six rectangular parallelepipeds specimens (size of specimens: 15 cm × 15 cm × 100 cm) were cut from the ice sheet at the experimental site, and the modulus of flexural elasticity and the flexural strength were calculated from the three-point bending test of a simple beam.