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Experimental Study of Behavior of Ice Floe Run-up Caused by Tsunami

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This paper aims to investigate through experiments the kinetic momentum of ice floes carried by a tsunami. In the experiment, 2 types of model slope were installed in a 24-m-long wave tank, and a solitary wave was generated. The movement of model ice sheets was observed by video camera. The model ice sheets were made of polypropylene whose friction coefficient against the bottom of the model slope was about the same as that of an ice floe and a sandy beach.

INTRODUCTION

The Sea of Okhotsk along the northern coast of Hokkaido is covered with ice floes every year (Fig. 1). In those years when many ice floes cover the area, they reach the Pacific coast via the Nemuro Straits.

On March 4, 1952, a large earthquake (M = 8.0) caused serious damage in the eastern part of Hokkaido. The earthquake is known as the Tokachi-oki Earthquake (Long. 143°52′E, Lat. 42°09′N). The tsunami following the earthquake attained 1 to 3 m in wave height and hit the eastern coast of Hokkaido from Nemuro to Cape Erimo. The tsunami's scale was not very large, and serious damage was not expected. However, Kiritappu Town was hit by ice floes that ran up on land with the tsunami-caused rise in water level; this occurred because the town is on a tombolo (Fig. 1) between Hamanaka and Biwase bays, with its center on lowland approximately 2 m above sea level, and the tsunami coincided with the ice floe season in winter (Fig. 2). Personal and physical damage was thus heightened. In the stricken Kiritappu area, breakwaters have now been established to prevent such damage in the future. The purpose of this study is to clarify the run-up height and traveling speed of ice floes when they run up on land because of a tsunami, and to study the ice force that is applied to gates and other parts of a sea wall when hit by ice. Cammaert et al. (1983) proposed an equation to find the impact force of ice sheets from the kinetic energy and momentum of ice. In this study, then, changes in the speed and kinetic energy of run-up ice sheets were verified through a model experiment.

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KEY WORDS: Sea ice, ice run-up, tsunami, Sea of Okhotsk.

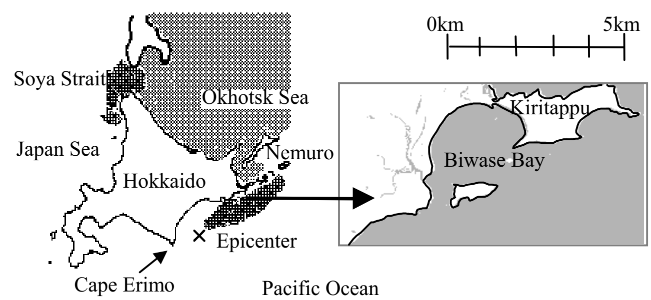

Fig. 1 Ice floe distribution and Kiritappu Town

EXPERIMENT

Experimental Setup

The experiment was conducted in a 24-m-long wave flume with a concrete slope installed in the bottom. The modeling scale was approximately 1/25 according to Froude similitude. Two types of channel bottom shapes were used for the experiment: a continuous slope with an inclination of 1/30 as Case 1; and a slope with an inclination of 1/30 to the shoreline and a breakwater on horizontal bottom on the landward side of the shoreline as Case 2. In Case 2a, the model breakwater was installed on the horizontal bottom, 10 times as long as the breaking wave height H_b from the shoreline. In Case 2b, it was placed $5H_b$ from the shoreline (Fig. 3).

To study the run-up mechanism of ice sheets, in both Cases 1 and 2, a model ice floe was placed on a still-water surface and a solitary wave generated as a model of a tsunami in a shallow water area. Four types of waves—13.7, 12.0, 10.0 and 7.0 cm in breaking wave height H_b—were used for the experiment. These are equivalent to a wave height of 1.8 to 3.5 m in real scale, corresponding to the wave height when damage was sustained at Kiritappu.