The XIV Finnish Mechanics Days 2022
May 18–20, 2022, Lappeenranta, Finland

Large-scale fracture experiments of warm and floating columnar freshwater ice

Iman E. Gharamti1*, John P. Dempsey2#, Arttu Polojärvi3*, Jukka Tuhkuri4*

* Department of Mechanical Engineering
Aalto University
Espoo 00076, Finland
e-mail: iman.elgharamti@aalto.fi
arttu.polojarvi@aalto.fi
jukka.tuhkuri@aalto.fi

Department of Civil and Environmental Engineering
Clarkson University
Potsdam, NY 13699, USA
e-mail: jdempsey@clarkson.edu

ABSTRACT

Ice fracturing (splitting) often occurs when an ice floe interacts with various types of offshore structures (icebreakers, ships, bridge piers, etc.). It is important to study fracture because it plays an important role in determining the ice loads on offshore structures. In fact, global warming is making the ice warmer, thinner, and fragmented. While cold ice has been typically studied in the literature, it becomes highly important to investigate and model the fracture of warm ice. The mechanics of the ice may be fundamentally different when it is warm, very close in temperature to zero degrees, than cold.
This paper reviews a fracture study case of warm columnar freshwater ice (>-0.5°C). Large-scale fracture experiments, using edge-cracked rectangular plates loaded at the crack mouth, were conducted in the Ice Tank of Aalto University. The plates covered a size range of 1:39, the largest for ice tested under laboratory conditions, with three plate sizes: 0.5m x 1m, 3m x 6m and 19.5m x 36m. The monotonic loading rates applied led to test durations from fewer than 2 seconds to more than 1000 seconds, with some experiments tested under creep/cyclic-recovery loading. Under the monotonic loading, size and rate effects were interrelated as rate dependent size effects and size dependent rate effects. Under the creep/cyclic-recovery conditions, the ice response was surprisingly elastic-viscoplastic with no significant viscoelasticity.

Keywords: ice, fracture, size effect, rate effect, viscoelasticity.