

This paper draws conclusions about the micro scale physics that takes place during the recovery of strength of ice after thermal cracking. The physical behavior is deduced from a series of tests: full surface thermal cracking (no data shown); narrow band thermal cracking (previously presented in Murzda et al., 2022a); repeated cycles of cracking and healing (no data shown); compressive stress influence on healing (no data shown); creep-assisted crack tip blunting by cycling (data presented in Fig 3). The arguments are coherent and the experiments appear to support the authors' conclusions. However I believe the paper would be significantly improved if their data were presented in figures (histograms, box plots, etc).

Presentation of data: Data presentation is especially important as the paper draws on new, as well as previously published data, to come to microstructural conclusions. The authors are careful to delineate the previously published work. On line 117-120, they state “the full-surface thermal cracking, repeated cracking–healing, compressive-creep, and sea-ice cyclic-loading experiments are newly reported here. Some cyclic-loading results from Murdza et al. (2023) are also reinterpreted in the context of creep-assisted crack-tip blunting.” However the lack of new experimental data in the paper leave the reader wondering about their number and quality. I also felt there were details missing that I would have liked.

Surface temperature calculation: It seems that the surface temperature of the ice was simulated (see Supporting Information) rather than measured. Were there any “calibration” experiments to check that the correct order of magnitude was simulated. For example, what is the justification for choosing the value of the heat transfer coefficient? In addition, was the latent heat of the phase change of the liquid nitrogen taken into account? Surely the temperature change would be very dependent on the volume of liquid nitrogen discharged. Was this carefully controlled?

Experimental parameters: What was the frequency of cycling in the creep-assisted crack tip blunting? How are time and cycles distinguished from each other in these experiments? How many experiments were performed in all cases where flexural strength is quoted with an error.

Minor comments and typos

Line 50-51: “the present study aims to explore how thermal shock and subsequent healing impact the flexural strength of both freshwater ice and sea ice.” Was the work carried out in order to understand the physics of the healing of thermal cracks in ice; or was the aim to simulate ice in its natural environment?

Line 102: “underlying”

Lines 181-189: The data on healing after full-surface thermal cracking are not presented. These could be displayed as, for example, histograms of flexural strength values for each condition. Or as box plots? How many experiments were performed?

Line 191: Fig 2 (which is Fig 2 of Murzda et al., 2022a with the normalized temperature added) is referred to in line 191 before the description of the normalization (lines 230-236). The normalization description could be given in the Methods.

Line 200: Rather than “comparable” I would say “within error”

Line 210-214: How many experiments? Does it matter how long the ice crept under compression? No data are presented.

Line 216-226: Frequency of cycling? It would be interesting to have these data presented, and to know the number of tests, rather than just have the flexural strengths stated.

Line 236-239: Flexural strength experiments seem to have been conducted in clusters, within 1s, between 4-10 s and from 300s after cracking. Thus the strength recovery time can either be vague or needs to be defined. The reader also needs to know the uncertainties in the simulation of surface temperature in order to assess whether it is reasonable to state that “surface temperature recovers **significantly** faster than strength”

Line 276-279: It would increase the impact of this paragraph if there were data presented.

Line 280: “a narrow band of the **freshwater** ice”

Line 335: I don’t understand what the “real” and “apparent” area of the contact face mean. This is made more confusing because subscript r is used to mean “recovered” and to mean “real”. Please could you also briefly explain why the recovered strength is proportional to the ratio of real to apparent contact area.

Lines 337-349: I think that the effective bending stress of 0.5 MPa is used on line 342 because of the applied outer-fiber stress of 1 MPa in test sequence (iv)? However this is explained, without reference to 1 MPa in test sequence (iv), **after** the calculation. Again it would be much more impactful if the reader was presented with the data.

Line 355: Fig 3 does not have time and we are not told the frequency of cycling.

Line 359-361: “by Renshaw and Schulson (2001), crack blunting dominates crack growth”

Eq (6): What is σ_e ?

Line 363: Where does σ_r appear? What is c ?

Eq (7): What is c ?

Eq (8): Are n and B the same as in Eq (5)? What is E ?