

An Integrated Constitutive Theory for the Mechanical Behaviour
of Sea Ice: Micromechanical Interpretation

S. S. Sunder

Massachusetts Institute of Technology

INTRODUCTION

Ice in general, and columnar sea ice in particular, is a very complex material which exhibits a wide range of behaviors often at the same time. As a consequence of its occurrence at high homologous temperatures, the mechanical behavior of ice is strongly influenced by temperature and rate of loading. In most applications ice behaves as a material undergoing both continuum deformation and cracking activity. Microcracking activity can be effectively idealized as continuum behavior and represented by models describing multi-axial flow with appropriate modifications to account for the damage due to micro-cracking. This type of damage manifests itself as strain-softening observed during constant strainrate tests in compression and as tertiary creep in compressive creep tests. On the other hand, macrocracking activity implies "failure" of the material at macroscale and is a separate behavioral mechanism. A constitutive model that captures both the mechanisms of multi-axial flow as a continuum and ultimate failure by macrocracking in addition to the rate and temperature dependence is necessary to investigate the mechanics of deformation and progressive failure in ice.

Previous modeling work directly relevant to the development of such a constitutive theory is limited since most investigators have treated ice as either an elastic-plastic or a viscoelastic material under multi-axial states of stress. They include the works of Glen (1955), Palmer (1967), Shapiro (1978), Sinha (1978, 1979, 1983b), Michel (1981), Wang (1982), Morland and Spring (1981, 1982, 1983), and Ashby and Duval (1985). Studies on the damage behavior of ice have been relatively few in comparison. Sinha (1982) and Sanderson and Child (1984) have studied the occurrence of first cracks in ice under compressive creep conditions, while Schulson (1979, 1984a,b)