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Modeling snow slab failure in propagation saw test using Drucker-Prager model

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Abstract

Fracture propagation in weak snow layers followed by the failure of overlying homogeneous snow slab leads to the formation of snow slab avalanches. The extent of fracture propagation in the weak layer and size of the avalanche release area depends on the mechanical behavior of overlying snow layers. To model the snow slab failure in slab avalanche formation process, in present work, mechanical behavior of natural snow is studied through high strain rate (1×10^{-4} s^{-1} or higher) uniaxial tension and compression experiments on natural snow layers. Uniaxial loading and unloading experiments are also carried out to understand the permanent strains at high strain rates. Elastic modulus of snow is derived from loading unloading test data and compared with the tangent modulus obtained from maximum slope of the stress-strain curve. Tensile and compressive strengths are derived from peak load at failure and fracture energy is derived from post peak stress-strain curve. For a density range of 100-400 Kg/m^3 the range of obtained mechanical properties of natural snow are: Elastic modulus: 0.1-45 MPa, Tensile strength: 0.24-20 kPa, Compressive strength: 0.1-105 kPa, Fracture energy: 0.007-0.15 J/m^2. For low density snow (<150 Kg/m^3) tensile and compressive strength values are quite close but for higher densities compressive strength is significantly higher than the tensile strength. At low strain rates ($<1\times10^{-4}$ s^{-1}) snow generally exhibit no failure and large permanent deformations whereas, at high strain rates (1×10^{-3} s^{-1} or higher) failure strains are generally in the range 0.05-1.5 %. In all cases a sharp decrease in load at failure suggests a near brittle failure. By fitting the experimental dataset with power law, density dependent expressions for elastic modulus, tensile and compressive strength are obtained. On the basis of the experimental observations, a continuum elastic-plastic-damage material model is considered to model mechanical behavior of snow layers. To model the asymmetry in tensile and compressive strengths, pressure dependent Drucker-Prager model is considered for yield criterion and model parameters (friction angle and cohesion) are obtained using density dependent expressions of tensile and compressive strength of snow. Effective plastic strain based damage initiation and evolution models are used to model quasi-brittle failure of snow. This model has been used for modeling the snow slab failure in two dimensional propagation saw tests and the obtained results on the influence of slab density, thickness and

slope angle on slab failure have been presented.