Size Effects in Slab Avalanche Fractures

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Abstract: Size effects in snow failure are an important aspect of avalanche release. A size effect implies that larger samples have smaller strength than smaller samples. Slab avalanches release by propagation of fractures: first in shear in the weak layer and then in tension at the crown. In a fundamental sense, then, slab avalanche fracture toughness (in shear and tension) govern slab avalanche release. Since snow strength (in shear or tension) is an important component of fracture toughness, size effects will play a role in determination of the fundamental definition of fracture toughness. Snow strength (in shear or tension) has no meaning by itself in snow slab instability: it is only a very important component of fracture toughness.

Two basic types of size effect have been proposed for snow: fracture mechanical size effects (in shear and tension) and statistical size effects including Weibull and Daniels (bundle) models. In this paper, I provide estimates of the fracture mechanical size effect laws for both weak layer shear fracture and crown tensile fracture with the constants evaluated entirely from in-situ field data (avalanche fracture line data and in-situ strength tests). In addition, I also provide the Weibull size effect law for tensile fracture evaluated from field data. Principal results include: 1. determination of the ratio of tensile to shear fracture toughness for the snow slab; 2. determination of a length scale at the bottom of the snow slab which is the highly stressed region for which crown tensile failure initiates (important for evaluation of hardness changes in snow profiles); 3. from the perspective of alpine snow as a quasi-brittle material, a Weibull size effect law is not expected to apply unless slab thickness is very large (several meters); 4. a Daniels (or bundle model) statistical model implies no size effect for shear failure in the weak layer. Instead, it implies only that the variance of strength is reduced for larger samples. This latter result suggests that recent attempts to model snow slab failure using cellular automata are incompatible with the concept of size effects in snow mechanics.

Key words: size effect, avalanche fractures, tensile, shear, snow mechanics

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