Geophysical Research Abstracts
Vol. 18, EGU2016-2704, 2016
EGU General Assembly 2016

An analytical approach for the Propagation Saw Test

Lorenzo Benedetti (1,2), Jan-Thomas Fischer (2), and Johan Gaume (3)

(1) CIMNE - International Center for Numerical Methods in Engineering, Barcelona, Spain , (2) BFW – Austrian Research Centre for Forests, Department of Natural Hazards, Innsbruck, Austria, (3) WSL – Institute for Snow and Avalanche Research SLF, Davos, Switzerland

The Propagation Saw Test (PST) [1, 2] is an experimental in-situ technique that has been introduced to assess crack propagation propensity in weak snowpack layers buried below cohesive snow slabs. This test attracted the interest of a large number of practitioners, being relatively easy to perform and providing useful insights for the evaluation of snow instability. The PST procedure requires isolating a snow column of 30 centimeters of width and -at least-1 meter in the downslope direction. Then, once the stratigraphy is known (e.g. from a manual snow profile), a saw is used to cut a weak layer which could fail, potentially leading to the release of a slab avalanche. If the length of the saw cut reaches the so-called critical crack length, the onset of crack propagation occurs. Furthermore, depending on snow properties, the crack in the weak layer can initiate the fracture and detachment of the overlying slab.

Statistical studies over a large set of field data confirmed the relevance of the PST, highlighting the positive correlation between test results and the likelihood of avalanche release [3]. Recent works provided key information on the conditions for the onset of crack propagation [4] and on the evolution of slab displacement during the test [5]. In addition, experimental studies [6] and simplified models [7] focused on the qualitative description of snowpack properties leading to different failure types, namely full propagation or fracture arrest (with or without slab fracture). However, beside current numerical studies utilizing discrete elements methods [8], only little attention has been devoted to a detailed analytical description of the PST able to give a comprehensive mechanical framework of the sequence of processes involved in the test.

Consequently, this work aims to give a quantitative tool for an exhaustive interpretation of the PST, stressing the attention on important parameters that influence the test outcomes. First, starting from a pure mechanical point of view, a broad phenomenology of the main failure types of the PST is outlined. Then, the Euler-Bernoulli beam theory is applied to the test setup, allowing an easy description of the snowpack stress state in the quasi-static regime. We assume an elastic-perfectly brittle model as constitutive law for the snow slab. Besides, considering the weak layer as a rigid bed of crystals with an a priori inclination, a local instability problem is formulated in order to take into account the combined effect of compressive and shear loading. As a result, the onset of slab and weak layer fracture is described in terms of cut length, slab dimensions and the main mechanical parameters. A condition on the possible propagation of the crack is proposed as well.

References

[1] C. Sigrist and J. Schweizer, *"Critical energy release rates of weak snowpack layers determined in field experiments"*, Geophysical Research Letters, Volume 34, L03502, 2007.

[2] D. Gauthier and B. Jamieson, *"Evaluation of a prototype field test for fracture and failure propagation propensity in weak snowpack layers"*. Cold Regions Science and Technology, Volume 51, Issue 2, Pages 87-97, 2008.

[3] R. Simenhois and K.W. Birkeland. *"The extended column test: Test effectiveness, spatial variability, and comparison with the propagation saw test."* Cold Regions Science and Technology, Volume 59, Issue 23, Pages 210-216, 2009.

[4] J. Heierli, P. Gumbsch, M. Zaiser, *"Anticrack Nucleation as Triggering Mecchanism for Snow Slab Avalanches"*, Science, Volume 321, Pages 240-243, 2008.

[5] A. van Herwijnen, J. Schweizer, J. Heierli, *"Measurement of the deformation field associated with fracture propagation in weak snowpack layers"*, Journal of Geophysical Research, Volume 115, F03042, 2010.

[6] K. W. Birkeland, A. van Herwijnen, E. Knoff, M. Staples, E. Bair, R. Simenhois, *"The role of slabs and weak layers in fracture arrest"*, Proceedings of the International Snow Science Workshop, Banff, 2014.

[7] J. Schweizer, B. Reuter, A. van Herwijnen, B. Jamieson, *"On how the tensile strength of the slab affects crack*

propagation propensity", Proceedings of the International Snow Science Workshop, Banff, 2014.

[8] J. Gaume, A. van Herwijnen, G. Chambon, K. W. Birkeland, J. Schweizer. *"Modeling of crack propagation in weak snowpack layers using the discrete element method"*, The Cryosphere, Volume 9, Pages 1915-1932, 2015.