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Interactive comment on "Weak layer fracture: facets and depth hoar" *by* I. Reiweger and J. Schweizer

I. Reiweger and J. Schweizer

reiweger@slf.ch

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Reply to reviewer 2

We would like to thank the reviewer for the constructive suggestions. Below you find a point-by-point reply to the comments.

There is an intense debate in the avalanche community about shear vs. mixedmode collapse. This article is a nice contribution to this debate, but its conclusions over-simplify what is likely happening at the slope scale. In previous studies, there is a disconnect between observations of local failures (those directly under a load) and *those which self-propagate (failures larger than the loaded area). For instance, Compression Test scores have negative correlation with slope angle Jamieson (1999) while Extended Column Tests that propagate have scores with little or positive correlation with slope angle (Heierli et al., 2011; Bair et al., 2012). This article supports Jamieson (1999) and finds that sample strength decreases with slope angle. This finding seems valid for local failure, but invalid for self-propagation.*

Our findings concern only local failure (the 'initial failure'), we will state this more clearly, namely in the first sentence of the abstract, in the introduction (p. 1909, 13), at the beginning of the results (p.1910), and extensively in the discussion.

The authors may only be drawing conclusions about crack initiation, but they do so implicitly. Statements in the conclusion (p. 1914, 4-9) make unsupported leaps that weak layers generally fail in shear. If collapse comes after shear, then how do the authors explain remote triggering from flat ground? The authors should explicitly state the limitations of their sample sizes, which have a maximum length of 20 cm. Propagation Saw Tests, shear models (McClung, 2011), and mixed-mode collapse models (Heierli et al., 2008) indicate that critical lengths are often greater than 20 cm. The authors should state that they were unable to observe critical (i.e. self-propagating) cracks, or provide evidence to the contrary.

Within this paper we only study failure initiation not crack propagation. This is due to the restriction for sample size which was given by the dimensions of the loading apparatus. We will clearly state that crack propagation was not studied within our experiments.

We fully agree that collapse is observed during fracture - it is the natural result of a

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fracture in a porous media such as snow. The potential energy due to collapse may well contribute to crack propagation (Jamieson and Schweizer, 2000).

In regard to remote triggering one has to keep in mind that remote triggering is not directly related to failure initiation prior to the release of a spontaneous avalanche. During artificial triggering by over-snow travelers the loading conditions are different and do involve a shear component independent of slope angle.

The energy of an anticrack nucleus V_m is assumed to be insensitive to slope angle (Heierli et al., 2008, Eq.1):

$$V_m(r) \propto -r^2(\tau^2 + \sigma^2)$$

where r is crack length, τ is shear stress and σ is compressive stress. I suggest that the results in this article directly refute this assumption.

We agree that this is a possible interpretation of our experimental results.

The particle tracking methodology needs further explanation. It is not clear what particles are being tracked. Are they individual grains or clusters of grains? How does the fragmentation of these particles during failure affect the particle tracking? What is the uncertainty in displacement?

The PIV algorithm recognizes patterns on a photograph taken from the snow sample and tracks them over various subsequent photographs. The snow sample was sprayed with paint to achieve sufficient contrast for the PIV algorithm to find a pattern. In a set of validation experiments the accuracy of the displacement calculated by the PIV algorithm was found to be ± 0.01 mm.
We will write all this explicitly in the paper.
In case of severe destruction patterns due to grains spurting out of the sample during

catastrophic failure, the algorithm does not work anymore (pattern cannot be found on subsequent image).

I'd like the second author to specifically cite and explain how this work does not contradict his previous studies (e.g. Sigrist and Schweizer, 2007; van Herwijnen et al., 2010; Schweizer et al., 2011) that assume avalanches fail in a mixed-mode collapse wave.

For avalanche release both failure initiation and crack propagation are needed (Schweizer et al., 2003). In the papers Schweizer et al. (2011); Sigrist and Schweizer (2007); van Herwijnen et al. (2010) propagation saw tests are analyzed and material properties relevant for crack propagation are determined. In the present work on the other hand, we focus on failure initiation within a weak snow layer. Therefore our present study does complement the previous ones.

Fig. 2 – How did you measure strength for a sample that did not fracture? I do not see how the colors show order of magnitude. I suggest you drop the colors, they only clutter the figure.

We will give the strength value of the sample which did fracture and change all the colors to black (Fig. 1). The fact that one sample did not fracture is taken into account of marking the concerned data point with a circle instead of a square, and it is described as such.

Fig. 1. Strength for samples TRA and LAY as function of slope angle and loading rate (N = 11). The squares represent fracture, the circle indicates that one sample did not fracture at this tilt angle and loading rate.

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