Review #1:

Dear reviewer,

thank you again for your careful review of our manuscript. Below we have pasted your comments in blue, our point-by-point responses are given in black. Line numbers refer to the new “track changes file” of the revised Version of the manuscript.

As I stated in my previous review: The paper is well structured, clearly written and offers new relevant results. The title is fitting, and the abstract clear. It is an appropriate topic for NHESS and generally satisfies the criteria for publication in an international journal. Data from the field tests provides new evidence that is significant for both practitioners and researchers. In my opinion it will be suitable for publication following some explanation and clarification. That said, I have made some specific recommendations to be addressed that I hope will improve the presentation.

In this revised version the authors altered the development of the conversion models by introducing a cantilever beam to establish motivation for the development. This offers a reasonable approach. As presented, this resulted in the determination that the masses of the slab above the saw cut are equal for the normal and vertical configurations. The resulting model provided excellent results as demonstrated in figure 3a (for upslope cuts with vertical PST geometry), implying that the mass equivalence assumption may be appropriate. I think that the development equating the masses of the slab above the saw cuts in eq 1 needs to be clarified. While I could be misinterpreting something, I've tried to point out where I have some questions. Since eq 1 is the basis for much of the modeling, I think it is important that the assumptions are clear.

Examining the Conversion Models section:

Line 84: Assumes the cantilever beam does not deform sufficiently to contact the snow beneath the cut.

Indeed, the free hanging cantilever does not deform sufficiently to come into contact with the snow under the cut. We now added this information (line85)

Line 85: “combination of reaction forces…” Would normal force would be more appropriate here? These would all be reactions to the loading.

Thanks for pointing out. We revisited the sentence to be more explicit about the reaction forces. Line (90 – 92)

Line 92-93: “The maximum load a weak layer can support before fracture is reached at the critical cut length. Hence, also R is at a maximum at the critical cut length ($Rmax$).”

Even for a level cantilever beam there is also shear stress to be considered due to the bending moment, as you note in figure 4b. On a slope there will also be a shear as well as a normal component from the weight, also demonstrated in fig 4b. Failure depends on the properties of the weak layer and stress intensity from both the normal and shear stresses at the crack tip. It is likely a mixed mode failure. The ultimate compressive load may not necessarily be reached. For example, surface hoar may be stronger in compression than shear.

Correct, even a leveled cantilever has reaction forces, including a shear component. The picture of a levelled cantilever was drawn for simplicity. However, as we saw that it was misleading we revisited the sentence to not restrict to the flat cantilever anymore. (Line 93)

Line 99: “are independent of PST geometry” As presented in fig 4a, for a cut from the bottom if we were to assume equal critical cut lengths, the total mass, and thus resultant vertical loading above the intact weak layer, are not the same. The vertical configuration would have a greater load. If rN > rV, mass for of vertical configuration is larger, and for rV > rN the mass of the normal may be greater. Perhaps in the model these variations might be considered negligible for sufficiency long slabs. This may coincide with what you are saying on line 195. - 196.

True, edge effects stemming from the far end of the PST column are not considered in the models. In other words, we do not consider differences in the mass of the slab at the far end of the PST column. As elaborated around line 195, this assumption holds as long as the columns are long enough. No changes were made.

Next addressing the rest of the paper sequentially.

Caption in figure 1, lines 76-77: “HV the vertical measured slab thickness” The variable HV is referenced in the figure caption, but it does not explicitly appear in the figure. Nor does it appear explicitly in the paper. However, HN appears in the "Model application and limitation" section” (Lines 261 - 263). It is the same as D in this figure.

Thanks for catching this error. In last revision we changed the Nomenclature from HV and HN to D for the slab thickness.

Line 77“each slab layer i” consider adding, (in both the vertical and normal configurations)

Accepted

Line 126: “G” Should this be subscripted with a c to indicate critical? But you state that it depends on the geometric configuration, so, are you referring to the energy release rate and not the critical? The critical energy release rate is a material property, energy release rate is not.

G_c is correct. We changed.

Line 134: “asymmetrically layered slab” What is the asymmetry to which you are referring? Do you mean layers of different heights and material properties? You should explicitly define what you mean by this at this point in the presentation.

It appears also at lines 236-239.

Line 237: “inhomogeneous and asymmetrical slabs” Clarify the difference.

We elaborate homogeneity and asymmetry in the slab by including the lines 140-142:

“Uniform slabs or symmetrically (with respect to the centre height of the slab) layered slabs are simplifications, usually slabs have a density gradient so that deeper layers have a higher density and are therefore stiffer. However, the load models take very little account of the effects of asymmetric slab layering. “

Line 238: “density gradient within the slab (asymmetry)” So by asymmetry you mean density differences of the layers. In general, other properties as well? Which will have relevance for the LMM.

See answer above.

Line 142: “14 and 70 cm” Including both upslope and downslope cuts?

Line 143: “50%” Considering both upslope and downslope cuts, or only upslope? In conclusions (line 273) this is more specific at 48%.

For upslope cutting. We clarified (Line 150).

Line 150: “different deviations” Are you referring to the imprecision in the testing discussed in appendix B. If so, I suggest you express it a more explicitly here. Did you measure a deviation of angle β from slope normal (or vertical)?

No, differences in snowpack conditions (e.g. slab thickness, layering, …) at the various field sites resulted in different deviations between PST geometries. We slightly adapted the sentence to make it clearer(Line 158).

Line 176: “deviations” Which deviations? Same as line 150? Not the same as deviation of angle β from slope normal (or vertical). Line 330?

We deleted “*deviations”* as we saw it is distracting. We just meant differences in measured critical cut lengths due to different PST geometries (vertical vs. normal geometry).

Line 161: “in vertical geometry rcV” Were results similar for the normal geometry?

This is important to note, since differences in geometric configuration is a substantial inquiry of the paper. Does the model apply for both downslope cuts as well as upslope?

We just converted the normal configuration to the (modelled) vertical geometry. Which was then compared to the measured vertical critical cut length. However, Equation 3 can easily be reformulated to do the conversion the other way around ($r_c^{\mathrm{N}} = r_c^{\mathrm{V}} - \frac{\tan(\gamma)D}{2}$). Mathematically, it can also be shown that the RMSE is identical if we model the r_c^{N} from r_c^{V}.

$$RMSE(r_c^{\mathrm{N}}\ modelled) = RMSE\ (r_c^{\mathrm{V}}\ modelled)$$

$$r_c^{\mathrm{N}} - r_c^{\mathrm{V}} - \frac{\tan(\gamma)\,D}{2})^{\wedge}2 = (r_c^{\mathrm{V}} - r_c^{\mathrm{N}} + \frac{\tan(\gamma)\,D}{2})^{\wedge}2$$

→ True

Does the model apply for both downslope cuts as well as upslope?

In the vertical configuration, as we elaborate in lines 224, the load over the saw cut is always the same, independent of the cutting direction. The load models do not apply. The difference in measured critical cut lengths are attributed to the shear stress at the crack tip (See lines 225-232). For the slope normal PST geometry the load models are able to explain the “greater” observed difference (compared to the difference in vertical geometry) → see Lines 219 – 222. The models, therefore, apply partly.

line 166: “colors” Might add (corresponding to fig 2a)?

As this (now line 175) is the caption of figure 2a, we consider your suggestion as redundant.

Line 261: “factors A and contributions B in Equation 1…” This section is difficult to comprehend until appendix B has been examined. Possibly a short summary at this point would help with the flow of the presentation.

We now provide an example (different from appendix B) of such a “contribution” in lines 267-269.

Line 167: “critical cut lengths” for upslope cuts?

Yes, we added this information (Line 176)

Line 169: “the layered mechanical model (LMM)” I'm not clear on how these critical cut lengths are calculated. Are they derived from previously determined critical energy release rates? But aren't the critical cut lengths to determine the critical energy release rates?

Indeed, the calculation process is outlined in lines 124 – 143. Basically, it is a two-step approach to model r_c^{N} from a measured r_c^{V} is:

1. Use r_c^{V} + “vertical configuration” as input of the LMM to compute the critical energy release rate of the weak layer (G_c^{V}).
2. Use G_c^{V} + “normal configuration” as input for the LMM to back calculate the modelled r_c^{N}.

Line 262: “slab thickness (HN,$\tilde{H}$N)” HN is equal to D in fig 1d.

We fixed this.

Line 272: “PSTs with slope normal beam ends systematically produce shorter critical cut lengths (48% on average)” Is this considering both cut directions or only upslope?

For upslope cutting. We added the missing information in Line 283.

Line 309: “Volumes B and C” As sketched, B and C are for the top layer. Should indicate that they are meant to be representative of the similar shaped volumes for each i layer.

The Volumes of each layer. In the revised Version we clarified that (Line 321).