EVALUATING A PROTOTYPE FIELD TEST FOR WEAK LAYER FRACTURE AND FAILURE PROPAGATION

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ABSTRACT: Researchers and practitioners currently lack a quantitative field test that indicates the propensity of a given slab and weak layer combination to propagate weak layer fracture and failure to an extent that leads to avalanching. We report on the development of such a test and the evaluation of a prototype test method. This test allows researchers to observe propagation and arrest away from the initial weak layer failure by extending the down slope dimension of the small column stability test. Weak layer failure is initiated by cutting the weak layer with a 2 mm thick snow saw either from the upslope or down slope end of the isolated column. Depending on slab and weak layer characteristics, weak layer fracture/failure propagates from the edge of the saw and propagates either to the end of the column, to an indistinct point, or to the vicinity of a fracture through the thickness of the slab. During the winter of 2006, University of Calgary researchers performed over 600 of these tests in the Columbia Mountains of British Columbia, Canada, and the Rocky Mountains in Alberta, Canada. Results of our experiments allow for an evaluation of the relationship between isolated column length and cut length required to initiate propagation in this test. In addition, we evaluate the limited slope dependence and cut direction dependence of test results. We show that under certain conditions associated with nearby avalanche activity, a critical cut length emerges that is independent of slope angle; propagation under these conditions arrests only at the end of the isolated column. We discuss these results in terms of both shear fracture and weak layer collapse theoretical models.

KEYWORDS: fracture propagation, field test, extended column, snowpack stability, avalanche forecasting

1. INTRODUCTION

The failure in a weak snowpack layer that leads to a slab avalanche starts at a point and propagates up, down and across the slope. The result is often a large avalanche if the snowpack has a pre-existing propensity to propagate such failures. Existing snowpack stability tests are probably better at evaluating the likelihood of weak layer fracture and failure initiation than the likelihood of it propagating rapidly and widely. Therefore, avalanches sometimes occur unexpectedly when existing methods indicate stability. Schweizer et al. (2003) highlighted the need for a better understanding of the propagation process, and specifically recommended that future research seek to provide a means to test for propagation propensity in the field.

Both the shear fracture mechanics (FM; i.e. McClung 1979, 1981; Bazant et al., 2003; Louchet 2001a, b) and the weak layer collapse (WLC; Heierli, 2005; Heierli and Zaiser, 2006) models describing propagation provide descriptions of how a flaw or crack (initiation) in a weak layer might start to propagate. Both types of theoretical models predict that the higher the propagation propensity of a given snowpack, the smaller the initial failed area needs to be to trigger propagation at a given stress level, although they differ in describing what ‘propagation propensity’ means physically. In general, the current FM models are restricted to sloping snowpacks, whereas WLC models describe propagation on horizontal terrain (e.g. whumpfs). Gauthier and Jamieson (2006a) discussed recent observations suggesting that the WLC models could apply to

Photo 1. Example of the field test configuration on horizontal terrain. The weak layer is highlighted with contrasting colour. (ASARC Photo)

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sloping terrain; Schweizer and Kronholm (2006) included components of collapse failure and shear fracture in their conceptual model, and calculations showed that shear fracture might be the dominant failure mode only on steeper slopes (Sigrist et al., 2006). In FM models, low *fracture* 'toughness' or 'resistance' at the weak layer describes high propagation propensity. The equivalent property in WLC models is resistance to structural *failure* by a succession of *fractures* in the ice-skeleton of the weak layer. In this paper we use the term 'fracture propagation' without bias for the FM or WLC description of the progressive fracture processes that may lead to failure of a weak snow layer's ability to provide vertical and shear support to overlying layers.

In this paper, we report on the evaluation of a prototype field test for propagation propensity (Photo 1). We used a test-column geometry that allows for quantitative observations of propagating fractures (Gauthier and Jamieson, 2006b), and a method of initiating propagation that is consistent with both WLC and FM theories (Gauthier and Jamieson, 2006a). This test allows us to observe propagation and arrest away from the trigger of weak layer failure by extending the down slope dimension of the small column stability test. Fracture propagation is initiated by cutting the weak layer with a 2 mm thick snow saw either from the upslope or down slope end of the isolated column. We consider this saw-cut that leads to propagation in the field test to be analogous to the flaw or crack on a slope that propagates and leads to avalanche release, and we expect that where propagation propensity is high a shorter cut length will be required for propagation to cross the test column.

Based on results collected in the winter of 2005, Gauthier and Jamieson (2006a) described several possible relationships between the isolated column length and the cut length in this test in a given snowpack. They showed that in some cases a large proportion of the test column must be undercut prior to any propagation occurring, meaning that longer columns would require longer cuts (constant proportion; CP). Some of their data, like that of Sigrist et al. (2006), showed that cutting a consistent absolute length of weak layer (critical length; CrL) would initiate propagation, regardless of column size.

In this paper, we report on approximately 600 tests performed in the winter of 2006. We use these results to evaluate our test method and further define the relationship between the length of saw cut and the column size in different snowpacks, and the role of fracture arrest in the column in defining propagation propensity. In addition, we attempt to assess the effect of slope angle and cut direction on test results. We discuss these relationships in terms of FM and WLC processes, and describe the further development of test geometry and methods.

2. METHODS

2.1 *Test geometry*

For this study, we used a similar isolated column geometry to that presented by Gauthier and Jamieson (2006b), but here we initiate propagation as described by Gauthier and Jamieson (2006a). The method is identical to that presented in Sigrist et al. (2006). Simenhois and Birkeland (this volume) present a similar geometry in their across-slope 'extended column test'. Our test columns were completely isolated from the surrounding snowpack to a depth below a weak layer of interest, 30 cm wide in the cross-slope direction, and between 0.2 m and greater than 4 m in the down slope dimension (Fig. 1a). The test column usually had one side and the down slope end completely exposed by shovelling. The remaining side and upslope end were isolated from the surrounding snowpack using a vertical saw cut or by cutting with a cord. Rarely, we exposed all sides of the column by shovelling where other methods of isolation were impractical. We initiated weak layer fracture propagation by quickly drawing a 2 mm thick (5 cm wide) steel saw blade through the width of the weak layer plane, beginning at one end of the test column. Generally, we felt little resistance to the passage of the saw in weak layers of varying hardness and thickness; however, we rejected tests with non-planar cuts or with uncertainty in the precision of the cut. Most often, we preferred to lead with the non-serrated side of the saw blade, as the slab may be difficult or impossible to cut with the blunt edge. This technique aided the operator in passing the saw blade through the weak layer only.

In the majority of tests, we observed weak layer fracture propagation initiating from the leading edge of the saw blade. In some cases, it quickly propagated across the entire length of the column (Fig. 1b), whereas other times a distinct break through the thickness of the slab interrupted it within the isolated area (Fig. 1c). Less frequently, we found that propagation arrested at an indistinct and often difficult to identify point along the test column (Fig. 1d). Performing the test with highly smoothed and planar side and end walls aided the identification of the extent of weak layer failure and any breaks through the slab.

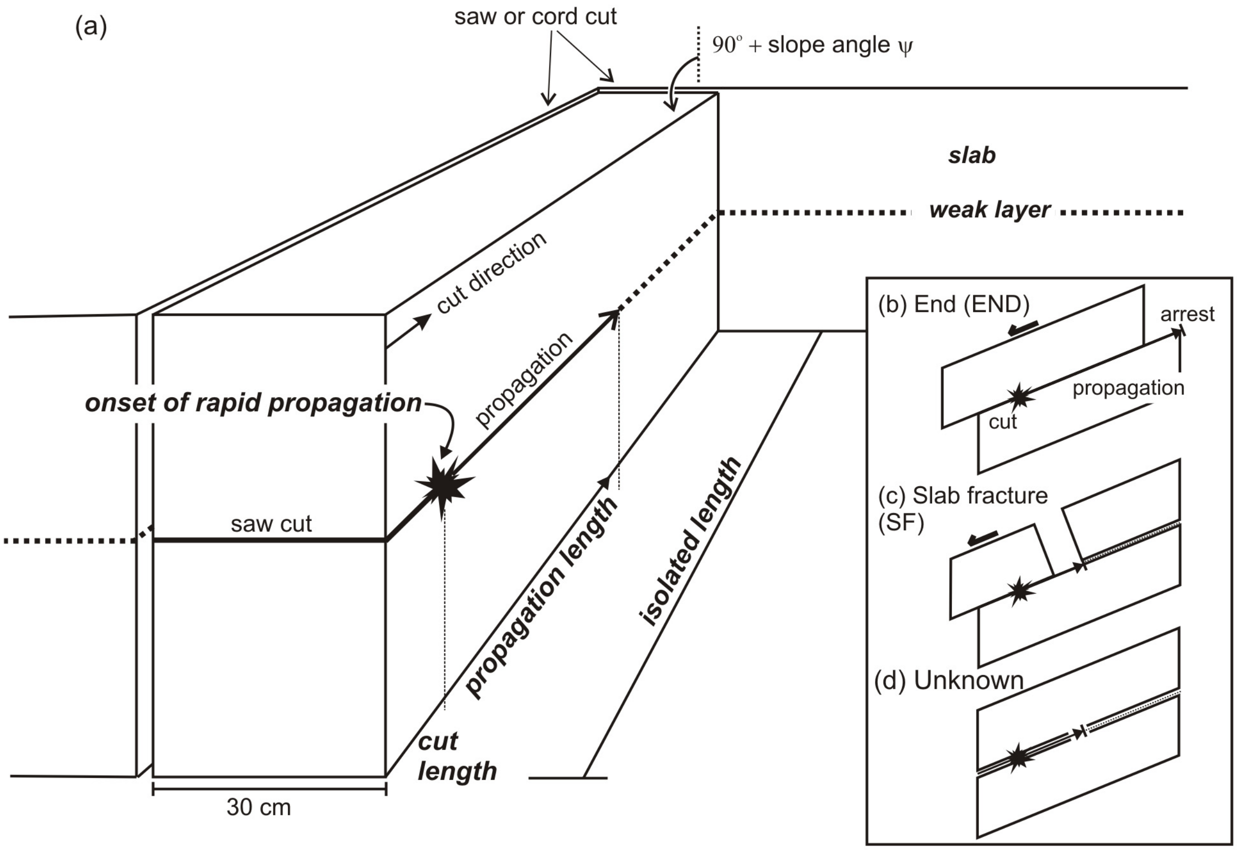

Figure 1. Schematic diagrams of the test method and relevant parameters and variables. (a) Perspective view of the isolated column geometry, with relevant parameters and variables indicated. An 'upslope' cut direction is indicated; however, 'down slope' cuts are possible. Inset shows profile views of the isolated column, highlighting (b) propagation to the end of the column, (c) arrest of propagation in the vicinity of a fracture through the thickness of the slab, and (d) arrest at an otherwise indistinct point.

2.2 Experimental variables

The objective of this study was to determine the influence of several experimental variables on the results of the prototype test, and thereby develop a consistent methodology for future tests. Table 1 summarizes the experimental variables considered here.

We designed our field experiments such that the relationship between cut length and column length could be determined as accurately as possible. On most experiment days we attempted to sample as many different column lengths as possible, generally beginning at a length approximately equal to the slab thickness, progressing up to many metres in some cases. To avoid any complications due to large variations in snowpack properties we generally only compared results collected on the same day in the same location. To evaluate the cut direction and slope effects, we ensured that we had collected a satisfactory sample of column lengths prior to changing slope angle or cut direction, after which we made every effort to sample the same distribution of column sizes. This type of sampling allowed us to compare only the cut length distributions between groups of tests performed on different slopes or with different cut directions.

3. RESULTS

During the winter of 2006, University of Calgary researchers performed 612 of these tests in the Columbia Mountains of British Columbia, Canada, and the Rocky Mountains in Alberta, Canada. We worked with the prototype test on 39 different days and on 14 different weak layers, and we attempted to conduct tests with varying snowpack properties. We tested very soft to stiff slabs, ranging in thickness from 13 cm to 248 cm. In addition, we tested persistent (surface hoar, facets, depth hoar) and non-persistent (new snow, decomposing fragments, rounds) weak layers. In the following sections, we discuss the relevant results in terms of the different test variables listed in table 1.

3.1 *Cut Direction*

In the winter of 2006 we dedicated ten experiment days ($n = 193$ tests) to evaluating the effect of cut direction on test results. On nine out of the ten experiment days, we found no significant difference in the cut length distributions of upslope and down slope tests (Mann-Whitney U-test: $p > 0.05$). Figure 2a shows the distributions of cut lengths in upslope and down slope directed tests from one of these experiment days. On one out of the ten experiment days, we found a significant difference in the cut lengths between cutting upslope and down slope (Mann-Whitney U-test: $p < 0.01$). Cut lengths in down slope tests ranged from 20 cm to 31 cm, with a median of 23.25 cm on this day. Upslope directed tests showed shorter cut lengths between 10 cm and 29 cm, with a median cut length of 17 cm.

3.2 *Slope angle*

Over the course of the 2006 season, we collected results from testing on slopes between 14° and 50°, with the majority between 25° and 35°. In addition, we collected approximately 80 test results on horizontal terrain ($\psi \approx 0°$). We dedicated four days ($n = 102$ tests) to evaluating the effect of slope angle on the relationship between cut length and isolated length. On three experiment days, we tested a range of isolated column lengths on two adjacent slopes with very similar snowpack properties. On one day, we compared 15° to 27° ($n =$ 9 and 5 tests, respectively), and found no significant difference in cut length distribution (Mann-Whitney U-test: $p > 0.05$). Most interestingly, we also compared tests from horizontal terrain and a 23° slope. These two sites are approximately 500 m apart; however, snowpack properties were sufficiently similar to support the comparison. We found no significant difference in the cut length distribution (Mann-Whitney U-test: $p > 0.05$) between the flat and sloping terrain in 31 tests on columns between approximately 40 cm and almost 300 cm long (Fig. 2b). On another experiment day, we compared results from horizontal terrain ($n = 23$ tests) with results from an adjacent slope that varied between 30° and 38° ($n = 9$ tests). Again, we found no significant difference in cut lengths between the two groups (Mann-Whitney U-test: $p > 0.05$). In these tests, we most often observed propagation arresting at slab fractures. When we compared propagation lengths between the two groups, we found a weakly significant difference (Mann-Whitney U-test: $p = 0.024$). Median propagation length on the flats was 23 cm, compared to 15 cm on the sloping terrain.

We also tested an arbitrary slope parallel plane (i.e. not cutting along a weak layer) in a homogenous test column on slopes ranging from 14° to 38°. We tested isolated column lengths between 88.5 cm and 95 cm. As we found that a very high (>95%) proportion of the column was cut in all tests, we attempted to correlate the ratio of cut length to isolated length

Table 1. Description of the experimental variables considered in this study (Fig. 1).

Variable	Abbreviation (units)	Description
Isolated column length	IsoL (cm)	Total down slope length of the isolated test column, measured slope parallel
Cut length	CutL (cm)	Total length of weak layer cut to initiate fracture propagation, measured slope parallel
Cut direction	UP, DOWN	The direction of the saw cut, either in the down slope or upslope direction
Slope	ψ (degrees)	Slope angle, measured from horizontal
Propagation length	PropL (cm)	Total length of column over which propagation occurred
Arrest	END, UNKNOWN, SF	Indicates propagation to the end of the column, to an indistinct point, or to a slab fracture.

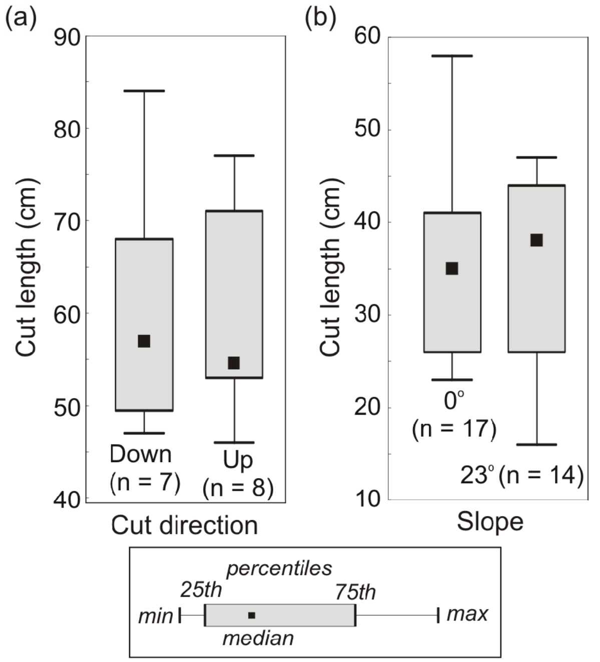

Figure 2. Box and whiskers plots showing the similar distribution in cut lengths between (a) tests conducted on 2 March 2006 with upslope and down slope directed cuts; and (b) tests conducted on 8 and 13 February 2006 in similar snowpacks on slopes of 0° and 23°. Differences between the distributions were insignificant in both cases (Mann-Whitney U test, p > 0.05), highlighting the insensitivity of test results to cut direction and slope angle in most cases.

with slope angle. The correlation was insignificant (Spearman R = -0.24, p = 0.37), indicating that the small variations in the ratio between tests could not be related to slope angle in this sample.

3.3 Isolated length

In total, we had 25 experiment days (*n* = 391 tests) available to analyze the relationship between cut length and isolated column length. Included in these were days that we set out to investigate this relationship specifically, meaning that cut direction and slope angle were controlled and remained constant. In addition, we included data collected on days with variable cut directions and slope angles where we found that the cut length distribution was insensitive to these variables.

By visual inspection of scatter plots comparing cut length and isolated length on each day, we grouped the experiment days based on the relationship between cut length and isolated length. Table 2 summarizes the groupings, based on Gauthier and Jamieson (2006a).

4. DISCUSSION

4.1 Cut direction and slope dependence

We found that on most experiment days (90%) the relationship between cut length and isolated length was not sensitive to the cut direction. Where there was some dependence, the cut length to isolated length relationship was a ‘critical length’ type. Among the experiment days that show no sensitivity to cut direction, there were two other days with ‘critical length’ type results. In both of these cases propagation progressed to the end of the isolated column in all tests, whereas fracture propagation generally arrested within the column on the day with cut-direction dependence. Therefore, we suspect that the cut direction sensitivity may relate to mechanical effects only observed where propagation arrests within the column.

Two main discussion points arise from the slope-effect results presented above: First, the fact that we can initiate propagation on horizontal terrain by simply cutting the weak layer with a 2 mm thick saw is a very interesting result. Johnson (2001) observed this in his cantilever-beam test, except he was cutting the weak layer with a 5 cm thick saw. We discuss this point in section 4.7. Second, our results indicate that the test method presented here is largely insensitive to slope angle; the only slope dependence we found indicated more extensive propagation on flat terrain than on adjacent slopes, specifically where propagation arrested at slab fractures. This suggests that the loss of shear support in the weak layer following fracture propagation on slopes may play a role in causing the slab fractures and the arrest of propagation.

4.2 Critical length

In each of the 10 experiment days where a critical cut length emerged, compression test results adjacent to the test columns yielded either sudden planar or sudden collapse fracture-character observations (van Herwijnen and Jamieson, *In Press)*. This behaviour occurred in both persistent and non-persistent weak layers, including surface hoar, facets, depth-hoar, and decomposing fragments. Some sampling bias may be included here, as we were more likely to test layers while they were exhibiting sudden-type fractures in compression tests.

In seven of these experiment days, we found that the critical cut length did not emerge until the isolated column length was greater than some critical value. In smaller columns, we found a constant proportion pattern (Fig. 3a). In three

Table 2. Description of the qualitative groupings of results in terms of the relationship between cut length and isolated column length (Fig. 1a)

Group	Abbr.	Criteria	Experiment days	n (tests)
Critical length (e.g. Fig. 3a)	CrL	▪ Constant cut length observed through most isolated column lengths; ▪ Most tests have CutL < 1/2IsoL	10	186
Constant proportion (e.g. Fig. 3b)	CP	▪ Cut length is a constant proportion of isolated length throughout; ▪ Usually CutL >> 1/2IsoL	7	94
Variable	VAR	▪ No obvious single relationship found; ▪ May contain evidence of both CrL and CP results	8	111

experiment days, this transition occurred where the isolated column length was approximately equal to the slab thickness, implying that a length greater than height geometry is required. In two other experiment days, we found the transition at column lengths approximately twice the slab thickness, and close to three times the slab thickness on a third experiment day (Fig. 3a). Notably, slab thickness in each of these was less than 30 cm. We did not test any column shorter than the slab thickness on the three experiment days where no such transition occurred, which suggests that these samples were insufficient to observe the transition. We also observed a transition in arrest style in five of the 10 experiment days. Here we found propagation to the end of the column in shorter columns, changing to arrest at indistinct points or slab fractures in longer columns. In three of these experiment days, the arrest transition coincided with the transition from constant proportion to critical length described above (Fig. 3a). Alternatively, on two experiment days the transition from end-seeking propagation to arrest occurred within the critical length portion of the results.

In column sizes smaller than these transition lengths, some size effect or artificial mechanics may be causing the slab-weak layer system to manifest a behaviour that is dependent on column size. Therefore, we assume that the arrest style and cut length behaviour observed in columns longer than the transition are more likely representative of the propagation propensity of that snowpack on the slope scale.

4.3 Constant proportion

On three experiment days with constant proportion results, we made slope-parallel cuts in arbitrary planes in a relatively homogenous test column as a control group. A minimum condition for choosing the location for these cuts was that we did not observe failures there in compression tests. Surprisingly, despite having a sudden planar fracture character in adjacent compression tests, some persistent weak layers behave similarly to the control group where no weak layer was present. In cases where weak layers were not present, the constant proportion was generally greater than 90%; however, we found that in three of the four persistent weak layer cases, the constant proportion was between 50% and 75% (Fig. 3b). In four of the seven experiment days included in this group, we found only minor differences in weak layer grain form or compression test results from those of the CrL group. We only found surface hoar as a weak layer grain type in these experiment days, and found only sudden planar fracture character.

4.4 Variable cut length

Members of this group are those experiment days that are not clearly members of the critical length or constant proportion groups. On some of these days, our sampling of various column lengths was not adequate to identify any clear relationship with cut length. In others, variation in cut lengths at similar isolated lengths is too large to permit evaluation of the relationship. We sampled persistent or non-persistent weak layers in each experiment day included in this group; however, in none of them did we observe a sudden planar or sudden collapse fracture character in nearby compression tests.

One explanation for the variable relationship between cut length and column size found on some days is that we were sampling a snowpack with high spatial variability. Unfortunately, our data do not allow evaluation of snowpack variability between test columns.

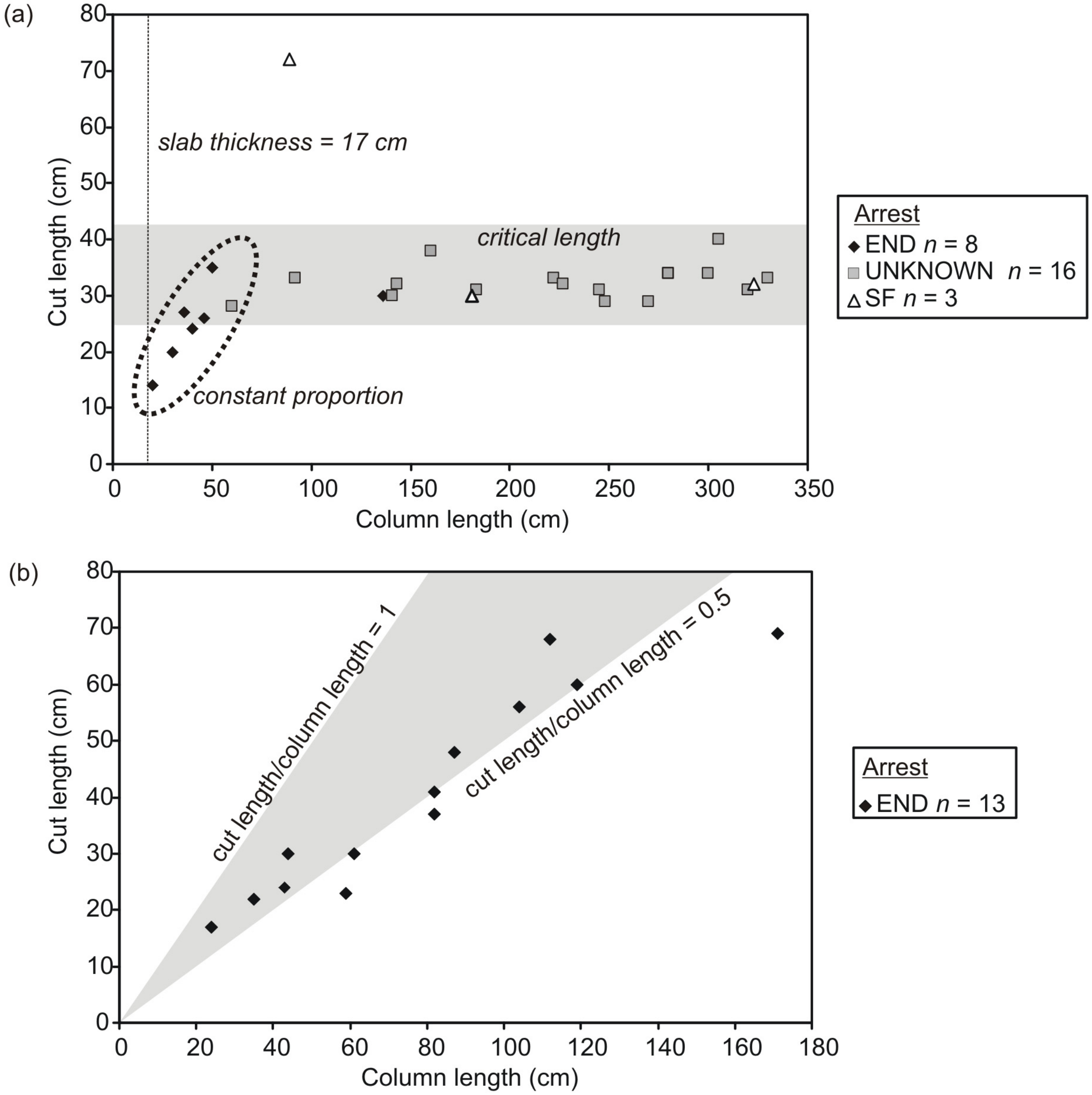

Figure 3. (a) Results of testing on 31 March 2006. The weak layer was surface hoar (6-9mm) below a 17 cm thick slab. A critical cut length, independent of column size, of 25-40cm existed where column lengths were longer than approximately three times the thickness of the slab. In smaller columns, cut length was dependant on column size, with a constant proportion type relationship and propagation crossing the entire column; (b) Results collected on 10 March 2006. In this case the slab was 55 cm thick and the weak layer was surface hoar (1-3 mm). Cut lengths showed a dependence on column size in this case, similar to tests performed in snowpacks lacking weak layers, although with a generally smaller constant proportion of the column being cut in this case.

4.5 Interpretation of test results

We expect that the expression of high propagation propensity in this field test should include extensive, uninterrupted propagation of fractures across the isolated column. Arrest within the column, at a slab fracture or indistinct point, may indicate that the slab-weak layer system is incapable of propagating fractures extensively. Alternatively, where we must cut a large proportion of an isolated column prior to the onset of propagation, the fracture may never really propagate. In terms of the results described here, only in cases where a critical cut length with propagation to the end of the column emerges are the conceptual criteria for high propagation propensity fulfilled. Simenhois and Birkeland (this volume) showed that extensive propagation without arrest or interruption in their extended column test correlated well with other indications of instability. While a rigorous proof of this hypothesis in our test is the subject of our future research, the example presented below supports the concept.

On 8 and 9 February 2006, we performed 14 propagation tests on an undisturbed slope within the boundaries of Kicking Horse Mountain Resort, near Golden, BC, Canada. The weak layer of interest was faceted crystals (2-4 mm) in a thick, soft layer close to the ground. We observed no change in snowpack conditions between the two days. Isolated length of the test columns ranged from 58 cm to 295 cm. Cut lengths required to initiate propagation ranged from 16 cm to 47 cm, and in every case fractures propagated across the entire column, with a visible collapsing of the weak layer. The slab was 141 cm thick at this location. We observed one sudden collapse in a compression test, and another in a deep-tap test. On 7, 8, and 9 February 2006, local operations reported 14 avalanches greater than size 2 (CAA, 2002) apparently releasing on the same layer of faceted snow. Each of these avalanches occurred within 60 km of our study site, and all were triggered artificially: one by a skier and one by a snowmobile (Jeremy Cox, personal communication), and the remainder by helicopter assisted explosive control. Most significant of these were three size 3 and one size 3.5 slides reported by CMH Bobby Burns and Bugaboos heli-skiing operations; both ran full-path. In their evening report to neighbouring operations, CMH Bugaboos reported that:

> "*Large triggers can produce spectacular avalanches, not easy to predict.*"

While far from providing a conclusive link between propagation test results and local avalanche activity, this example supports our expectation that where test results show extensive propagation with relatively short critical cut length, possibly indicating high propagation propensity in a given layer, we may see more frequent and larger avalanches releasing on that layer. Note that less than one week following the tests described above, we tested a nearby flat area and found that cut lengths were indistinguishable from those on the slope, indicating that slope independence accompanies the critical length and end-arrest when propagation propensity is high. Determining exactly how the results of this test correlate with local or regional avalanche activity is a priority of our future fieldwork.

4.6 Proposed Method

The purpose of the evaluation of variables in this study was to identify a test configuration, in terms of column size, cut direction and slope angle, which apply to all snowpacks. Such a method must allow users to determine whether or not a critical cut length exists and what the predominant arrest style is. Here we present an example configuration, based on our experimental results, that predicts group membership with one or two tests in a given snowpack.

Via a simple filtering process, we determined that for each day in our data set tests performed with an isolated column length equal to 1 m *or* to the thickness of the slab, whichever was greater, provided the data to predict group membership. If we had to cut greater than 50% of a 1 m (or slab thickness) long column, we could accurately place that day in the constant proportion group. Less than 50% cut on the same column and we could assume that if we continued to test longer columns we would get similar cut lengths. In addition, in tests at the proposed length or longer, we find no cases of an arrest-style transition, so that the arrest at that point predicts the arrest at greater column lengths.

Given the unknown within-sample variability and the effect of cut direction on the arrest style, we would recommend performing two tests of slightly different column lengths and different cut directions. Note that these recommendations *are not* based on any correlations with snowpack stability, propagation propensity, or avalanche activity; in a future study we will attempt to specify these relationships using a similar rule to that presented here.

4.7 Applications to fracture/failure theory

FM theories require that a critical length exists for all configurations, provided we test large enough columns to minimize size effects (Sigrist et al., 2005, 2006). Heierli's (2005) and Heierli and Zaiser's (2006) WLC model, though never applied to sloping snowpacks, allows propagation to occur only in appropriately collapsible stratifications, meaning that some slab-weak layer systems may not possess any propagation propensity at all. This allows for constant proportion type test results at any column length in snowpacks lacking propagation propensity. In many ways our results are like those predicted by WLC models: we found constant proportions where no collapsible weak layer was present *and* where weak layers were not *appropriately* collapsible, and found critical cut lengths in snowpacks with the ability to propagate fractures. Alternatively, we could argue that FM predicts this behaviour: our results are inconclusive on this point in that our column sizes were simply too short to determine the critical cut length in some cases. In other words, the same underlying size effects may have led to the constant proportions in all weak layers, whether we eventually discovered a transition to critical length or not. Our observation of a transition from constant proportion to critical length in some weak layers supports this explanation; however, both FM *and* WLC models could predict the transitions. Unfortunately, we would need to sample infinitely long columns to prove that a critical cut length always exists or that some snowpacks are unable to propagate fractures. Given the validity of both arguments, any interpretation of our results in terms of the different relationships and size effects is ambiguous, and therefore we cannot differentiate between the predictions of the models.

Heierli’s (2005) and Heierli and Zaiser’s (2006) propagation model of weak layer collapse applies specifically to horizontal terrain, although van Herwijnen (2005) observed propagating collapse on slopes. Alternatively, the fracture mechanics models provide details of a shear fracture process that may occur on slopes. However, a cursory examination of the collapse model shows that, conceptually, it could apply to sloping terrain in the absence of shear fracture, likely in some modified form (Gauthier and Jamieson, 2006a). The fracture mechanics models have difficulty explaining propagation on flat terrain in the absence of slope parallel shear, which we observe in whumpfs, remotely triggered avalanches, and our propagation test. In this study, we found no significant difference in the critical length required for propagation in two separate comparisons of sloping and horizontal terrain (e.g. Fig. 2b). Two possible explanations for this observation are (1) The independent critical length predictions of both models for the slab-weak layer system on these days were indistinguishable; or (2) The critical length measurements observed on the slopes and flats are indistinguishable because a single model describes this behaviour. At present, the latter seems the most likely. This may require abandoning the assumption that the primary failure leading to avalanche release is always in layer-parallel shear. Recently, Sigrist (2006) and Schweizer and Kronholm (2006) argued that slope normal bending in the slab due to a collapsing weak layer could contribute a significant portion of the required fracture energy, implying that some slope-dependant combination of shear fracture and collapse propagation could lead to avalanche release.

5. CONCLUSIONS

We reported on the development and experimental evaluation of a field test for weak layer fracture and failure propagation propensity. This test allows researchers to observe propagation and arrest away from the trigger of weak layer failure by extending the down slope dimension of the small column stability test (Gauthier and Jamieson, 2006a). Weak layer fractures are initiated by cutting the weak layer with a 2 mm thick snow saw either from the upslope or down slope end of the isolated column (Gauthier and Jamieson, 2006b). Results of over 600 tests performed in 2006 show that:

- The slope angle and the direction of the saw cut have little effect on the cut length required to initiate propagation in the test;
- This test is valid on horizontal terrain where propagation is expected. Test results from horizontal terrain are indistinguishable from the results of tests performed in similar snowpacks on slopes;
- In a given snowpack, the cut length required for propagation may be strongly dependant on or strongly independent of the column size beyond a minimum isolated column length. We argue that where a critical cut length emerges independent of column size and propagation never arrests within the test column the conceptual and theoretical requirements for high propagation propensity are fulfilled;
- Based on our results, a single test column with a length of 1 m or equal to the slab thickness, whichever is greater, provides sufficient information to predict the cut length dependence and arrest character of a given snowpack. A cut length of less than 50% of the column length indicates the approximate critical length cut length, and the arrest style will not change with longer columns. Longer cut lengths indicate the presence of a constant proportion type relationship;
- Weak layer collapse models for failure may explain the slope independence of cut lengths and cases where no critical cut length is found, even on slopes.

During our 2007 field campaign, we will attempt to correlate results of this test with local avalanche activity, standard stability test results, and snowpack properties. In addition, following the approach of Sigrist (2006), we will attempt to compare test results with the predictions of several theoretical models.

6. ACKNOWLEDGEMENTS

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