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An update on the Extended Column Test:
New recording standards and additional data analyses

Ron Simenhois[1] and Karl Birkeland[2]

[1]Copper Mountain Ski Area
[2]USDA Forest Service National Avalanche Center

1. INTRODUCTION

Avalanche release requires both fracture initiation and propagation, but most standard stability tests focus only on measuring fracture initiation. A few indirect methods, such as noting shear quality (Johnson and Birkeland, 2002) and/or fracture character (van Herwijnen and Jamieson, 2004) for small block tests or the amount of the block released for a rutschblock (Schweizer and Wiesinger, 2001), are being increasingly used. Still, no direct measures of fracture propagation existed for practitioners until two such methods were presented at the 2006 International Snow Science Workshop in Telluride. One method was Gauthier and Jamieson's (2006) Fracture Propagation Test. The second was our Extended Column Test (ECT) (Simenhois and Birkeland, 2006; Simenhois, 2006).

Since the ISSW we have had an overwhelmingly positive response to ECT, with users around the U.S. and even in the Pyrenees giving us positive feedback about its effectiveness. However, the recording method we presented originally proved to be cumbersome and confusing for many users. In addition, we felt that our original paper, which was based on data collected by only one individual, could be made much stronger with the inclusion of other results from more users. This short paper attempts to address these two concerns by: 1) Providing an updated recording standard for ECT results, and 2) Analyzing additional ECT data collected by numerous individuals in many different snow climates.

2. AN UPDATED RECORDING STANDARD FOR ECT RESULTS

Discussions with a number of individuals led us to the conclusion that we needed a new recording standard for the ECT. Our main goal in establishing a new standard was to try to emphasize what the test results are telling the user. Our results (Simenhois and Birkeland, 2006 and below) emphasize the importance of whether or not a fracture propagates across the entire column (now coded as ECTP) or not (now ECTN), and this needed to be reflected in the way the test results were recorded. In the end we came up with:

ECTPV – fracture propagates across the entire column during isolation,
ECTP## - fracture initiates and propagates across the entire column in ## or ##+1 taps,
ECTN – fracture doe not propagate across the entire column, or there are 2 or more taps between the initiation and propagation of the fracture, and
ECTNR – no fracture occurs during the test

3. ASSESSING THE EFECTIVNESS OF THE ECT WITH A MORE DIVERSE DATASET

3.1 Methods:

The growing acceptance of the ECT as well as the use of SnowPilot allowed us to collect more diverse data from different observers and mountain ranges. At the end of the winter we went through the season's entire collection of pits in the SnowPilot database and identified pits with ECT observations. Overall we found 127 pits from 14 different mountain ranges, 6 states and by 14 different observers. We believe this dataset offers an excellent comparison to the better controlled (though not as diverse) dataset used in our ISSW paper (Simenhois and Birkeland, 2006).

To decide if a pit is on a stable or an unstable slope in the SnowPilot data we relied on the observer's similar slopes stability rating, comparable to the methods used by Birkeland and Chabot (2006) for their analysis of false-stable stability tests. If the stability rating was good or higher, we rate the slope as stable, while ratings of poor or very poor put the slope in the unstable category. If the stability was rated as fair or there was no stability rating, we rate those slopes that had no signs of instability or have been skied with localized signs of instability as stable. Otherwise they rate as unstable. Clearly there are some flaws in this system since in some cases it relies on incomplete, subjective and inconsistent data. The slope rating is not as definitive as the techniques we used to separate out stable from unstable slopes in our ISSW paper (Simenhois and Birkeland, 2006). Still we feel the diversity of these data make them valuable, and that our technique is reasonable for our analyses.

Out of the 127 pits from SnowPilot, 53 pits (43%) were rated stable, 60 pits (47%) were rated as unstable and 14 of the pits (10%) were rated as unknown because the data was unclear or incomplete. We limited our analysis to the 113 pits we could characterize as stable or unstable using the technique outlined above.

Another data source included 31 pits from the Pyrenees sent to us by the forecasters from the Catalan warning center. In addition to ECT results, these data included compression or rutschblock tests with shear quality and stability rating from 1 to 5. Out of the 31 pits, 8 pits (25%) were on unstable slopes and 23 pits (75%) were on stable slopes.

In this report we analyze the combined data from SnowPilot and the Pyrenees (SP) totaling 144 pits (76 stable and 68 unstable pits).

3.2 Results and Discussion:

As we reported at the ISSW in Telluride, our first season's data (collected by the senior author) demonstrated the effectiveness of the ECT at discriminating between stable and unstable slopes. Of the 68 tests on unstable slopes, the fracture propagated across the entire column on the same or one additional loading step (ECTP) 100% of the time, and for the stable slopes the fracture propagated across the entire column in only 4 of 256 cases (1.6%) (Simenhois and Birkeland, 2006).

Our more diverse SP dataset also demonstrated the effectiveness of the ECT for identifying unstable slopes. Of the 68 tests on unstable slopes, 66 tests results in an

ECTP, while in only two cases (3%) did the fracture fail to fully propagate across the column (ECTN). This low rate of false-stability is encouraging and is less than a third of that reported for stability tests such as the compression test or the rutschblock (Birkeland and Chabot, 2006).

To better understand our two false-stable cases, we discussed them with their respective observers. The first case occurred on Dec. 12th, 2006 on a 40° slope at Bridger Bowl Ski Area in Montana in a pit dug by Doug Richmond. Stability on similar slopes was rated as poor, but Doug felt that it was safe to ski this particular slope. When we talked to Doug he said that similar slopes avalanched with control work but this slope didn't. When he dug the pit he felt that stability on this specific slope was good due to a lack of a cohesive slab on top of weak layers but needed to be watched carefully with more precipitation or a wind event. Given these observations, our method of declaring this an "unstable" slope might ultimately be the reason this test was classified as false-stable. The second case was on a 34° slope (that steepened to 38° below the pit site) in Idaho's North Smokeys on Feb. 23rd, 2007. On this slope Janet Kellam observed collapses on top of the slope and 5 m from the pit. Still, there were conflicting results in her pit. The ECT did not fully fracture (ECTN) and had a Q3 shear quality. However, a rutschblock test in the same pit popped with RB3 and Q1 shear quality. The weak layer was under a melt-freeze crust. No slides were triggered by those collapses or during the day and Janet felt that the slope probably would not have slid, but it certainly was one of those situations you prefer not to get caught so she decided to back off and not ski it. This is just one more reason why traveling the backcountry with a smart woman (and the President of the American Avalanche Association) is a good call!

The SP dataset does show a higher rate of false-instability than our original data. Of the 76 stable pits, in 12 tests from 10 pits (16%) the fracture propagated across the entire column (ECTP), a rate about 10 times higher than in our original data.

There are a number of possible reasons for the relatively high number of false instability cases. First and foremost, the data in the SP dataset are not as controlled as the original dataset. The original data involved only one observer applying the same standards to each of his slopes. Further, the delineation between stable and unstable slopes in those data could be better defined since most of the slopes were tested with explosives. A second possible reason is that the ECT aims to primarily test the snowpack propagation propensity. In order for slabs to release, fractures need to not only propagate, but they must first initiate. In other words, in some cases the snowpack propagation propensity may be high but fracture initiation is unlikely and therefore stability is high enough that instability could not be observed. This occurred in one of our cases of false-instability, where an extremely strong melt-freeze crust overlying moist depth hoar caused the observer to rate the current snow stability as good (despite the ECTP result), though he expected the stability to drop as the crust warmed and thinned.

The low rates of false-stability and false-instability emphasize the usefulness of the ECT as an additional tool for avalanche professionals. However, the presence of some misleading results highlights the necessity for avalanche workers to use a variety of snow stability tests and combine those test results with avalanche, snowpack and weather observations for effective avalanche assessments.

4. SPATIAL VARIABILITY OF EXTENDED COLUMN TEST RESULTS

Our ISSW paper reported results from a slope with 21 ECT results. The result of every test on the slope was ECTN, suggesting that, at least for this particular slope, ECT results were spatially uniform (Simenhois and Birkeland, 2006).

This past season we again conducted a spatial array of ECTs, this time on Tucker Mountain in Colorado. The array consisted of a 24 pit grid spanning an area 30 m across the slope by 20 m down a slightly convex slope with a 27° slope angle on the upper part of the grid and 33° at the lower part. We rated slope stability as fair, with the same aspect and elevation as other slopes that avalanched two days earlier with explosives and ski cuts. However the slab that avalanched was confined to the top 15 m of the ridge tops. In our grid we found similar conditions, with a slab similar to the slab that produced avalanches in the location of the upper 17 pits and a softer slab at the other 7 pits (Figure 1). ECT results on this grid were spatially uniform on the top 17 pits and on the other 7 pit but differ between the 2 groups of pits with ECTP in the top 17 pits and ECTN in the lower 7 pits (Figure 2). In the case of these results, there is a clear and explainable reason for the observed spatial variability, which is not always the case for the variability observed for some other tests which focus on fracture initiation (e.g., Landry et al., 2004). Indeed, the variability in ECT results observed appears to reflect the actual stability conditions on this particular slope.

5. CONCLUSIONS

Many different snow stability evaluation techniques exist. Our results suggest that the ECT is a valuable addition to our stability assessment toolbox. In particular, we are encouraged by how effectively the ECT identifies unstable slopes, and we are likewise encouraged by the spatial uniformity of ECT results in both stable and unstable areas.

Despite the promising results, we caution that our data are still limited. We have analyzed only two slopes to assess the spatial variability of ECT results so far. In coming seasons we plan to continue investigating the use of the ECT in other locations, with other snowpacks, and with a variety of observers to further validate its usefulness. Also, we remind readers that all stability evaluation techniques must be supplemented by additional information such as detailed avalanche and weather observations to effectively evaluate the snowpack stability. We encourage others to try the ECT in addition to their other tests, evaluate its effectiveness, and to share their results and experiences with us.

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Figure 1: An overview of the grid of 24 pits on Tucker Mountain in Colorado. The black line marks the lower boundary of the hard slab involved in avalanches on similar slopes two days before our sampling.

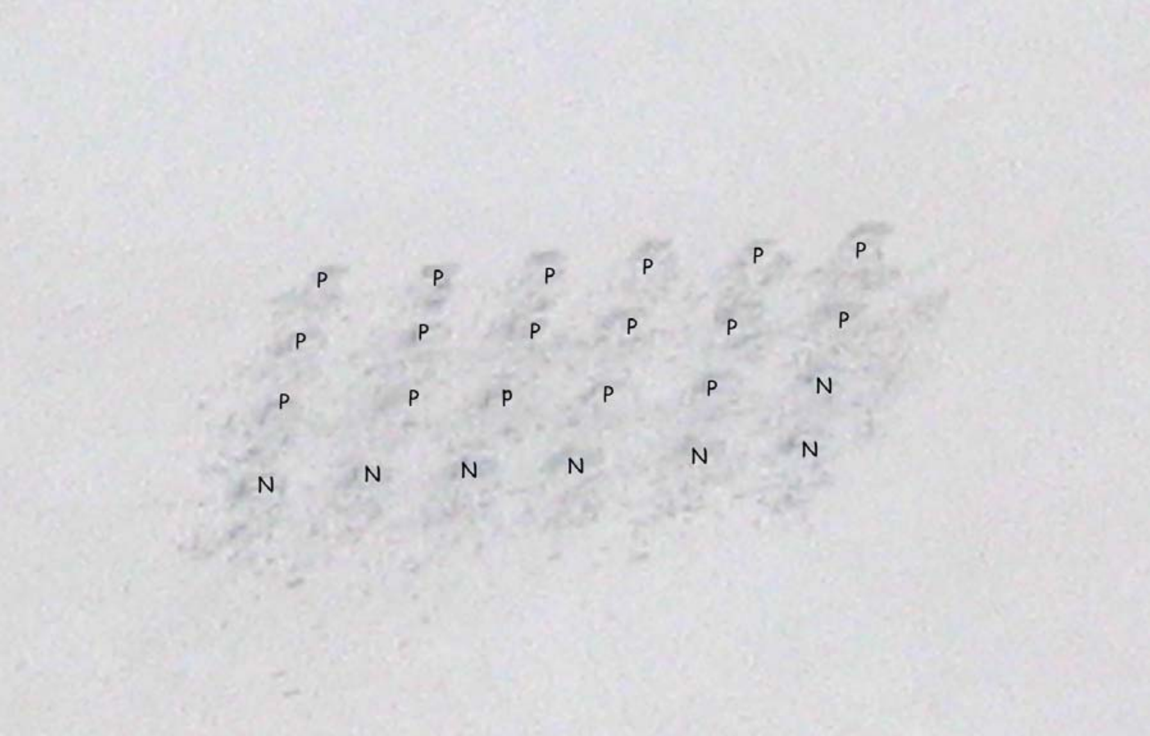

Figure 2: ECT results in the Tucker Mountain grid showing the locations with ECTP results (shown as “P”) and locations where the result was ECTN (shown as “N”). An active slab existed only at the upper left part of the grid, which is clearly reflected in the ECT results.