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The Extended Column Test: Test effectiveness, spatial variability, and comparison with the Propagation Saw Test

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ABSTRACT

The Extended Column Test (ECT) is a new stability test that aims to assess the fracture propagation potential across a 0.90 m wide isolated column. This paper: 1) describes the test procedure and presents new recording standards for the test, 2) uses two independent datasets (each consisting of over 300 tests) to assess the effectiveness of the test, 3) looks at the spatial variability of ECT results from several test grids, and 4) compares adjacent results between the ECT and the Propagation Saw Test (PST) on stable and unstable slopes. Our results indicate that the ECT is an effective stability test, with a false-stability rate less than other standard snow stability tests. Results are sometimes quite spatially uniform, though occasionally slopes may exhibit variable ECT results. In comparison to the PST, our data suggest that the ECT has a lower false-stability rate, but a higher false instability rate. Overall, the ECT is better at discriminating between stable and unstable slopes in our dataset. No test is perfect and all tests must be used in conjunction with additional data, but our results show that the ECT is valuable additional tool for assessing snow stability.

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1. Introduction

Avalanche forecasting relies on collecting diverse data, including data from the snowpack. The most highly prized snowpack data are what LaChapelle (1980) termed "low entropy" data or Fredston and Fesler (1994) call "bulls-eye" data. These are data that unambiguously inform the observer about the state of the snowpack, and include things like observing avalanches or hearing the snow collapse with a whumpfing sound (Johnson et al., 2004).

Other snowpack data might not be so unambiguous. For example, avalanche forecasters dig snowpits and do stability tests to help to ascertain whether the snowpack is unstable. However, interpreting stability tests is typically not straightforward, and most existing snowpit tests have false-stability rates around 10% (Birkeland and Chabot, 2006). In other words, when conducting such tests on slopes with clear signs of instability, observers can expect to get test results typically associated with stable slopes about 10% of the time. This value is unacceptably high and is why avalanche practitioners must use much more data than simply stability tests. Clearly, a need for better field stability tests exists.

The last few years have seen the development of two new tests. The Extended Column Test (ECT) (Simenhois and Birkeland, 2006) and the Propagation Saw Test (PST) (Gauthier and Jamieson, 2006a,b; Sigrist and Schweizer, 2007) both aim to investigate the fracture propagation potential of the snowpack. This is a critically important part of the avalanche puzzle since avalanche release requires both fracture initiation and fracture propagation along the weak layer (Schweizer et al., 2003; Gauthier and Jamieson, 2006b). Not only are these tests useful for stability evaluation, but they allow us to better investigate some of the factors associated with fracture propagation in the field, such as changes in slab depth (Simenhois and Birkeland, 2008a), snow surface warming (Simenhois and Birkeland, 2008b), and fracture propagation mechanics in weak snowpack layers (van Herwijnen et al., 2008).

The motivation for developing the PST and the ECT differed. Investigators developed the PST primarily as a fracture propagation test. On the other hand, we developed the ECT as a stability test. As with all stability tests, the primary goal of the ECT is to discriminate between stable and unstable slopes. Although not a pure fracture propagation test, we believe that the ECT does help to index the fracture propagation propensity of buried weak layers.

This paper synthesizes several recent papers on the ECT that have been written for practitioners (i.e., Simenhois and Birkeland, 2006; Simenhois and Birkeland, 2007; Birkeland and Simenhois, 2008) for the scientific community. The purpose of the paper is to: 1) describe the test procedure and document recent changes to recording standards for the ECT, 2) investigate the test's effectiveness for discriminating between stable and unstable slopes, 3) conduct a

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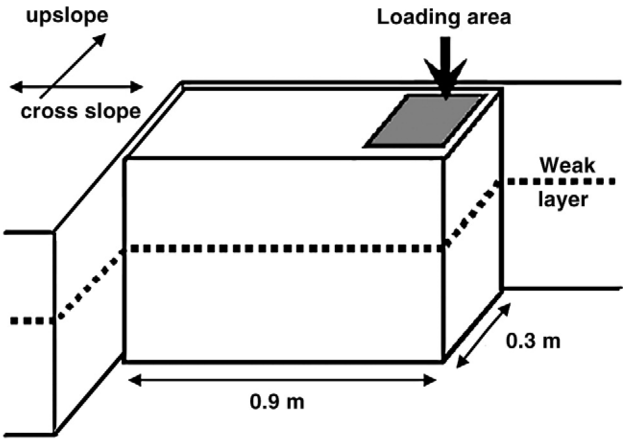

Fig. 1. The preparation of the ECT involves isolating a column 0.90 m across the slope by 0.30 m upslope. The column is then loaded from one side using the same technique as the compression test.

preliminary investigation of the spatial variability of ECT results, and 4) compare ECT results with results from the PST.

2. Extended Column Test procedure and recording standards

The Extended Column Test involves isolating a vertical column 0.9 m wide in the cross-slope dimension and 0.3 m deep in the upslope dimension that is deep enough to expose potential weak layers (Fig. 1). Depth should not exceed about 1.3 m since the loading steps rarely affect deeper layers. In fact, in our data the deepest test that propagated across the column was 1.04 m, and the deepest test that did not propagate across the column was 1.31 m. To conduct the test one end of the column is dynamically loaded using the loading steps of the compression test, whereby the tester taps a shovel ten times from the wrist, ten times from the elbow and then ten times from the shoulder (Greene et al., 2004). The observer notes the number of taps required to initiate a fracture in the weak layer below the shovel and whether or not the fracture propagates through the weak layer across the entire column.

The original recording standards for the ECT presented by Simenhois and Birkeland (2006) needed to be simplified and updated. The new standard better emphasizes what the test results are telling the user. Our findings, discussed later in this paper, emphasize the importance of whether or not a fracture propagates across the entire column, and this is reflected in the recording standards:

ECTPV—fracture propagates across the entire column through the weak layer or interface during isolation,
ECTP##—fracture initiates and propagates across the entire column through the weak layer or interface on the ## tap *or* the fracture initiates on the ## tap and propagates across the column on the ## + 1 tap,
ECTN##—fracture initiates on the ## tap but does not propagate across the entire column through the weak layer or interface on either the ## or the ## + 1 tap, and
ECTX—no fracture occurs in the weak layer during the test.

An advantage of the ECT is that test interpretation is straightforward. ECTPV and ECTP## results suggest unstable conditions because fracture propagation propensity is relatively high, while ECTN is generally indicative of stable conditions. With ECTX there is no fracture initiation, so we cannot evaluate the fracture propagation propensity for that layer. While an ECTX generally indicates stable conditions because fracture initiation is unlikely at the test location, previous spatial variability research shows that the force needed for fracture initiation can be widely variable across slopes (e.g., Campbell and Jamieson, 2007). Thus, we recommend using a different snowpack test when a user gets an ECTX result. Though the ECT is typically loaded with taps identical to the compression test, the same loading steps as the stuffblock test (Birkeland and Johnson, 1999) have been used by some researchers (Hendrikx and Birkeland, 2008) (Fig. 2).

3. Assessing ECT effectiveness

We use two independent datasets to test the effectiveness of the ECT in discriminating between stable and unstable slopes. Our first dataset consists of 324 tests conducted by the senior author during the winters of 2005/06 near Copper Mountain Ski Area in Colorado (202 tests) and Mount Hutt Ski Area in New Zealand (122 tests). These Colorado–New Zealand data cover two distinctly different snow climates and, since they are collected by a single observer, they are more consistent in data collection and in rating the slope stability. In addition, each pit includes all the typical snowpit observations described by Greene et al. (2004). Our second dataset comes from the SnowPilot database (Chabot et al., 2004) from 2006 to 2008 and is augmented with a number of tests from avalanche forecasters in the Spanish Pyrenees (Moner, pers. comm., 2007). Overall we found 311

Fig. 2. Though the ECT is typically loaded with the compression test loading steps (Greene et al., 2004), it can also be loaded using the stuffblock steps (Birkeland and Johnson, 1999), as shown above. From left to right: loading the extended column, column fractures (ECTP), examining the fractured slab and weak layer. Photos by Jordy Hendrikx.