Effectively Using and Interpreting Stability Tests

(Paper presented at the 1998 ISSW, Sunriver, Oregon)
Ron Johnson* and Karl Birkeland

ABSTRACT: Determining the likelihood of an avalanche occurring on a given slope is a critical decision faced by both avalanche professionals and backcountry enthusiasts. An important part of that decision-making process is using stability tests and interpreting their results. Though a variety of stability tests are available, we use the rutschblock and stuffblock tests since they both identify weak layers in the snowpack and, to a limited extent, quantify the stresses necessary for weak layer failure. However, there are several limitations to these stability tests, including site selection and interpretation of results, both of which require experience. While site selection may be the most important limitation, we focus on the interpretation of results. Such interpretations can be problematic, since those without the benefit of avalanche experience often latch onto stability test values as an absolute indicator of stability. However, our experience indicates that occasionally dangerous avalanche conditions exist when stability tests show a stable snowpack and that sometimes the snowpack is more stable than stability tests indicate. In order to partially address the difficulties in test interpretation, we have begun to qualitatively define the quality of the shear failure into three separate categories. This paper will focus on combining the interpretation of rutschblock and stuffblock tests, and describing the shear failure quality, thereby giving useful qualitative field information about the avalanche conditions in a given location. In the end, users must realize that stability tests do not provide a numerical description of the snow stability, but are instead just a piece of the puzzle for avalanche prediction.

KEYWORDS: snow stability, stability tests, avalanche forecasting, avalanches

* *Corresponding author address:* Ron Johnson, Gallatin National Forest Avalanche Center, Bozeman, MT 59771; tel: 406-587-6984; fax: 406-597-6804; email: rjohnson/r1_gallatin@fs.fed.us

1. INTRODUCTION

Stability tests are important because they help us to interpret the current snowpack stability, and to anticipate future avalanche problems. Numerous stability tests are available, and most experienced avalanche workers have a personal favorite. For a review of many of the tests, see McClung and Schaerer (1992). The bottom line is that any test is a good test if the user has enough *practical experience* to use the test to form a *reasonable assessment* of the snow stability. Those without practical experience, such as students in avalanche courses or people with limited experience, may find interpreting stability tests to be confusing. Likewise, experienced avalanche professionals working with a complex or unfamiliar snowpack may find test interpretation difficult. This paper presents our personal method for interpreting the stability tests we find most useful.

Inexperienced people face two main problems when applying stability tests: selecting an appropriate site for the test, and interpreting the results. This paper does not deal with site selection, even though selecting the appropriate test location is extremely important. Instead we focus on the interpretation of the results, which is critical for evaluating slope stability. If the snowpack is less stable than the interpretation, it might be hazardous to your health or career. On the other hand, if the snowpack is consistently more stable than your stability interpretation, you stand the chance of missing out on some great turns for either yourself or your clients. The most effective way we have found to interpret stability tests involves:

1) using both the rutschblock and stuffblock stability tests, and 2) rating the quality of the shear failure.

2. STABILITY TESTS USED

The rutschblock test (Föhn, 1987) is widely used by practitioners and scientists, and a good relationship between test results and snow stability has been established (Jamieson, 1992; Jamieson, 1995). Advantages of this test are that it provides a "feel" for the weaknesses within the snowpack for the tester and it tests a relatively large (about 3 m^2) area. However, like all tests, it has its shortcomings. Rutschblocks may miss weaknesses in the upper snowpack, they consume enough time that doing several tests in one area is rarely done, and, in some situations, they may underestimate deep slab instabilities (Jamieson (1995) provides such an example). The stuffblock test (Johnson and Birkeland, 1994; Birkeland and others, 1996) is a newer stability test that has become increasingly used by practitioners, has been correlated to the rutschblock test, and has also been used for scientific work (Birkeland, 1997). The primary advantage of the stuffblock test is that it provides uniform results between observers and between tests. Additional advantages are that it picks up weaknesses in the upper snowpack, it can be quickly repeated, and, our observations indicate that it may better estimate deep slab instabilities. Disadvantages of the stuffblock test are that it does not provide a "feel" for the weaknesses involved and it tests a relatively small area.

3. TEST INTERPRETATION/EVALUATION OF SHEAR QUALITY

The advantages and disadvantages for the rutschblock and stuffblock are summarized in Table 1. By using both tests, and recognizing the limitations in each, we are able to capitalize on the advantages of each test and thereby come up with a more accurate analysis of the current snow stability. This analysis allows the tester to "feel" the snowpack and test a larger area as s/he does the rutschblock, while taking advantage of the uniform results and short time required for the stuffblock test. In a typical snowpit we identify and analyze the snowpack layers, and begin our stability evaluation by conducting a stuffblock test. We usually do two or three stuffblock tests since once the pit wall is excavated it is relatively simple to isolate a number of columns of snow for testing. While doing this we note whether or not the test results reflect the conditions we expected on that slope, and if the side-by-side test results are consistent. Consistent results between tests obviously give us greater confidence in our interpretation. Then the pit wall is smoothed over and we conduct a rutschblock result. Again, we look for consistency between our expected results and the results of the two stability tests.

TABLE 1: Advantages and disadvantages of the rutschblock and stuffblock tests. Check marks indicate the advantage of that particular test. By recognizing the limitations of each test we feel we can capitalize on the advantages of both tests.

Rutschblock Test	Stuffblock Test
✓Tests a large area	Tests a smaller area
✓Provides a "feel" for the instability	Does not provide a "feel" for the instability
✓Good relationship between test result and snow stability	✓Good relationship between test result and snow stability
✓Compression test	✓Compression test
Results only somewhat uniform (depending on the weight of the tester, how hard they jump, etc.)	✓Uniform test results
Time consuming	✓Can be quickly repeated
Typically does not pick up upper level weaknesses	✓Typically identifies upper level weaknesses
May underestimate deep slab instabilities in some cases	✓May better estimate deep slab instabilities

Even when using both tests, interpretation requires experience and is not easy. In order to further facilitate the interpretation of results we began qualitatively assessing the quality of the shear failure on a scale from Q1 (unusually clean shear) to Q2 ("average" shear) to Q3 (rough or "dirty" shear) (Table 2). Shear quality assessment has given us one more way to interpret test results. It has also allowed us to better communicate results between each other and to explain results to students. As in several areas of avalanche forecasting, there is no clear-cut guideline for how much emphasis should be placed on shear quality. However, we certainly consider Q1 shears to be more significant than Q2, and much more significant than Q3, even when the actual test results are the same.

4. CONCLUSIONS

Numerous snow stability tests are available, and everyone has their favorite test or combination of tests. At the Gallatin National Forest Avalanche Center our preference is to use both stuffblock and rutschblock tests. By recognizing the advantages and disadvantages of each test, we feel that this combination gives us the best available tool to assess the snow stability. In addition to the stability tests we have begun qualitatively assessing shear quality, and we also feel this allows us to better interpret and communicate results.

TABLE 2: Qualitative ratings of shear quality used with the stuffblock test (and subsequently used with compression and rutschblock tests).

Shear Quality	Description
Q1	Unusually clean and smooth shear plane, weak layer may noticeably collapse during failure. Slab typically slides easily into the snow pit after weak layer failure on slopes steeper than 35 degrees, and sometimes on slopes as gentle as 25 degrees.
Q2	"Average" shear, shear plane appears mostly smooth, but slab does not slide as readily as Q1. Shear plane may have some small irregularities, but not as irregular as Q3. Shear failure occurs through the whole block being tested, and slab may or may not slide into snowpit.
Q3	Shear plane is uneven, irregular or rough. Shear failure may not occur through the whole block being tested. After weak layer failure, slab moves little, or may not move at all, even on slopes steeper than 35 degrees.

REFERENCES

Birkeland, K.W. 1997. Spatial and temporal variations in snow stability and snowpack conditions throughout the Bridger Mountains, Montana. PhD Dissertation, Department of Geography, Arizona State University, Tempe, Arizona. (Available through University Microfilms International, Ann Arbor, Michigan).

Birkeland, K.W., R.F. Johnson and D. Herzberg. 1996. The stuffblock snow stability test. Technical Report 9623-2836-MTDC. U.S. Department of Agriculture Forest Service, Missoula Technology and Development Center, Missoula, Montana, 20 pp.

Föhn, P.M.B. 1987. The "Rutschblock" as a practical tool for slope stability evaluation. In *Avalanche Formation, Movement, and Effects*, Proceedings of the Davos Symposium, September, 1986. IAHS Publ. No. 162, 223-228.

Jamieson, B. 1995. Avalanche prediction for persistent snow slabs. PhD Dissertation, Department of Civil Engineering, University of Calgary, Calgary, Alberta, Canada.

Jamieson, B. and C. Johnston. 1992. Experience with rutschblocks. *Proceedings of the 1992 International Snow Science Workshop*, Breckenridge, Colorado, 150-159.

Johnson, R.F. and K.W. Birkeland. The stuffblock: a simple and effective snow stability test. *Proceedings of the 1994 International Snow Science Workshop*, Snowbird, Utah, 518-526.

McClung, D. and P. Schaerer. 1992. The Avalanche Handbook. The Mountaineers, Seattle, Washington, 271 pp.
