THE SWISS "RUTSCHBLOCK" SNOW STABILITY EVALUATION TEST[1]

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Abstract — Conventional backcountry shear tests of the snow pack are compared with the Swiss Rutschblock test on steep, stable slopes. Conventional tests use a variety of levering tools and the Rutschblock uses a skier on the slope to reveal potential failure planes. In the Swiss test gradual static and dynamic loading yields one of seven degrees of slab strength, while conventional lever-shear tests result in a more subjective five-class rating of slab performance. Results show the conventional lever-type shear tests to be too sensitive and therefore not consistently representative of snow pack stability in the context of backcountry ski travel.

INTRODUCTION

Most avalanche workers will agree that we still cannot draw the line between a potentially stable and unstable weakness until failure has occurred (Perla, 1978). This is because it is difficult to predict the degree of propagation of potential shear fractures and because there may be only a slight distinction between the critical tensile stresses on stable compared to potentially unstable slopes (Ferguson, 1984). Therefore there is no simple procedure by which the winter backcountry traveler can reliably assess the avalanche hazard of mountainous routes. In practice, slope stability evaluation is a general, subjective interpretation of a large set of inputs: the history of storm cycles and the associated avalanche events, slope angle, orientation, and vegetation, information from snow pits, and tests of the relative strengths of layers and layer interfaces. Usually a test of the fracture toughness of a snow pack can provide only an index to the stability of a slope. Hence the various inputs are limited in the amount and type of information available, but together provide a general picture useful to the experienced backcountry traveler.

BACKGROUND

There seem to be as many ways to conduct a shear test as there are elementary backcountry safety courses. The shovel shear test is a traditional method used by backcountry travelers to aid evaluation of the stability of snow layers from snow pits. Other simple shear tests incorporate skis, poles, and various tools to lever the snow layers exposing planes of weakness. Results vary depending on the shovel size, type of ski or other tool, insertion depth, angle, and length, and operator experience. They also depend on whether the overburden has been removed and on the size of the column excavated, because shear strength measurements are sensitive to the volume disturbed (Perla, 1977). The problem with these techniques is that they often do not reflect a realistic stability index for backcountry touring because of the variation in results and the difficulty in relating the tool-produced failure to the effects of a skier on the surface. Shear tests that depend on gadgets are usually restricted to a small sample area and do not provide a realistic fracture disturbance compared to a skier.

Ski tests offer an appropriate test of fracture toughness because they sample a large volume quickly and efficiently. Moreover, they provide a stability index appropriate to the triggering mechanism in question; the skier. Conventional ski tests requiring the skier to enter the slope in question can be risky and should not be performed in remote areas. The method described here is a ski test, but is performed from the aspect of a reference site on a similar slope and a snow pit. The Rutschblock is a mini-slab that reveals potential shear planes by introducing shear stress from the snow surface. It has been calibrated as a stability criterion with other methods such as the stability index, and concurrent avalanche frequency by Föhn (in press). Like many other tests, it is site-specific and should be used in conjunction with other methods such as snow profile evaluation, and analysis of meteorological parameters, etc., for example as described by Perla and Martinelli (1978).

We compare the results of conventional "tool-produced failure" tests and the Rutschblock (or "Rutschen Block") ski test.

METHOD

The methods tested are site specific and do not involve testing the actual slope in question. Instead they are based on analysis of the characteristics observed on a representative slope from a snow pit. The snow pit should be in a safe area as close as possible to the aspect, slope, elevation, and snow loading of the slope of concern, although sites near the top of crests or surrounded by large boulders should be avoided. The depth of the pit should be about 1 to 2 meters.

Lever-Type Shear Tests

A column is generally isolated along the back of a snow pit wall by cutting away the sides with the shovel. The pits are generally 1 to 1.5 meters deep unless deep slab instability is suspected. The width of the column as well as the depth of the cut is somewhat

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arbitrary and is usually based on the geometry of the shovel or tool to be used to check planes of weakness. In our tests we use shovels, alpine skis and nordic skis in a variety of pit configurations.

Once the column or block of snow is excavated, the shovel or ski is inserted along the back of the block where it connects to the pit wall. The tool is then pulled forward and layers will usually break off along the clean planes of layer interfaces. It is sometimes also necessary to remove some of the overburden of the layer under consideration in order to make the test. The ease of producing the shear failures is an indicator of how poorly the layers are bonded and is rated very easy, easy, moderate, hard, and very hard. In addition to the inherent strength of the pack, the type of tool used and the degree of slope control the force needed to produce failure.

Rutschblock Test

The Rutschblock test consists of seven levels of stability evaluation, relating specifically to inherent snow pack strength-stress relationships. This test is similar to other shear tests in that a three-sided rectangular block is excavated in a snow pit. The exposed block should be about 2 meters wide, or about ski length, and should extend about 1 to 1.5 meters from the back of the pit so that the area tested is about $3m^2$. Just as with other tests, the potential failure plane is not sustained by lower end pressure forces and shear forces at the flanks. However, the overburden is not removed and the triggering mechanism acts from the surface. The following sequence is performed.

Step 1: In areas with ''inter-mountain'' or ''continental'' type snow covers the back of the slab is detached from the back pit wall using a piece of rope or cord. If the block exhibits failure during the pit excavation or sawing out the slab, the hazard should be considered extreme, a dangerous situation.

Step 2: The skier stands parallel to the long axis of the block, allowing the ski tips to come to rest at an uncut uphill corner of the block. If this produces no failure, the skier gently stands atop the slab with skis spanning the gap between the flank trenches. If failure occurs as a result of this action, the hazard should be considered acute and the slope should be avoided.

Step 3: The skier gives a slight dynamic up and down motion (once) on the skis without jumping, compacting the surface layers. If failure takes place, the hazard should be considered high and the slope should be avoided. If the slope must be crossed, the safest precautions are taken, with skiers moving between safe spots, one at a time, with at least 10 meters separation.

Step 4: The skier jumps in place one time, making an effort to have the skis impact the snow evenly across the block on the upper edge of the slab. Failure at this point shows the hazard to be moderate, a suspicious situation. Some local instabilities may be expected on similar slopes and the use of other methods and proper route selection are essential.

Step 5: The skier jumps a second time onto the same upper edge of the slab. If failure takes place during this action, the hazard should be considered moderate, and the slope may be traversed with a high degree of normal ski mountaineering safety precautions.

Step 6: The skier jumps in place without skis, intensifying the stress peak. Failure at this point shows the hazard to be moderate to low, and representative slopes should be considered relatively safe excluding any dramatic changes in weather conditions.

Step 7: None of the previous actions produces clean failure planes. The slope should be considered relatively safe, still allowing normal backcountry precautions.

Comparison of Tests

During the spring of 1985 and the winter season 1985-1986 the various shear tests described were compared in side-by-side pits by USFS personnel and Mammoth Heliski, Inc. The slope angle, snow depth and shear ratings were among the data recorded and are presented in Table 1. In most cases more than one lever-type test was performed in the pits.

TABLE 1. Shear Test Results

Slope	Snow Depth	L. Shears	Rating	Swiss Test
32°	197 cm	4 at 37 cm	easy	step 7
28°	133 cm	2 at 60 cm	easy	step 7
		1 at 42 cm	mod.	
29°	135 cm	3 at 80 cm	v. easy	step 7
		1 at 120 cm	easy	
28°	170 cm	1 at 28 cm	v. easy	step 5
38°	167 cm	1 at 27 cm	easy	step 7
		1 at 109 cm	easy	
		1 at 147 cm	easy	
28°	175 cm	3 at 55 cm	easy	step 6
29°	180 cm	3 at 25 cm	easy	step 6
28°	229 cm	1 at 16 cm	mod.	step 6
29°	188 cm	1 at 56 cm	mod.	step 7
		1 at 64 cm	easy	
29°	70 cm	1 at 20 cm	easy	step 6
		2 at 39 cm	mod.	
		2 at 62 cm	easy	
		1 at 70 cm	mod.	
28°	150 cm	1 at 40 cm	mod.	step 6
		1 at 60 cm	mod.	
34°	127 cm	3 at 56 cm	mod.	step 7
		3 at 79 cm	easy	
		1 at 99 cm	mod.	
30°	199 cm	5 at 25 cm	hard	step 7
25°	100 cm	5 at 64 cm	easy	step 6
35°	100 cm	3 at 15 cm	easy	step 7
		2 at 56 cm	easy	
33°	320 cm	5 at 61 cm	mod.	step 7

Two things can be seen from the table. First, that there are not enough data points to make a statistical analysis worthwhile, and second, there is also not much variation in the Swiss test data. Therefore we will place the discussion of the results in the context of some recent work at the Swiss Federal Institute for Snow and

Avalanche Research, Weissfluhjoch/Davos, Switzerland.

DISCUSSION

As previously mentioned the Rutschblock method has been calibrated against the standard stability index and concurrent avalanche frequency by Föhn (in press). In his analyses the stability index using the natural body force of the pack, a stability index considering sudden human triggering mechanisms, and the occurrence of slab avalanches were used to check the predictive potential of the stability indices and the Rutschblock method. In general, the stability indices (S = shear strength / shear stress) properly described about 75% of the avalanche events, but only 50% success was shown for climax avalanches. The study also shows that the probability of slab avalanches decreases substantially with increasing Rutschblock degree. The data were obtained from 150 sample observations of shear conditions and 80 dry slab avalanche situations. A large variation in the Rutschblock data was attributed to improper site selection, which shows the importance of site selection.

It can be seen from Table 1 that the shovel shear and related tests produced "very easy" and "easy" ratings frequently when the Rutschblock test showed no hazard. Note also that most of the tests were performed on relatively steep slopes. In general the field observations show a dramatic variation in shear response for the tool-produced shear tests compared to the Swiss method for the same sites. Therefore we believe that shovel shear and related tests are too sensitive for reasonable field application where backcountry travel is concerned. Furthermore, we have adopted the Rutschblock test for our backcountry travel and avalanche forecasting program and have dropped other shear tests.

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