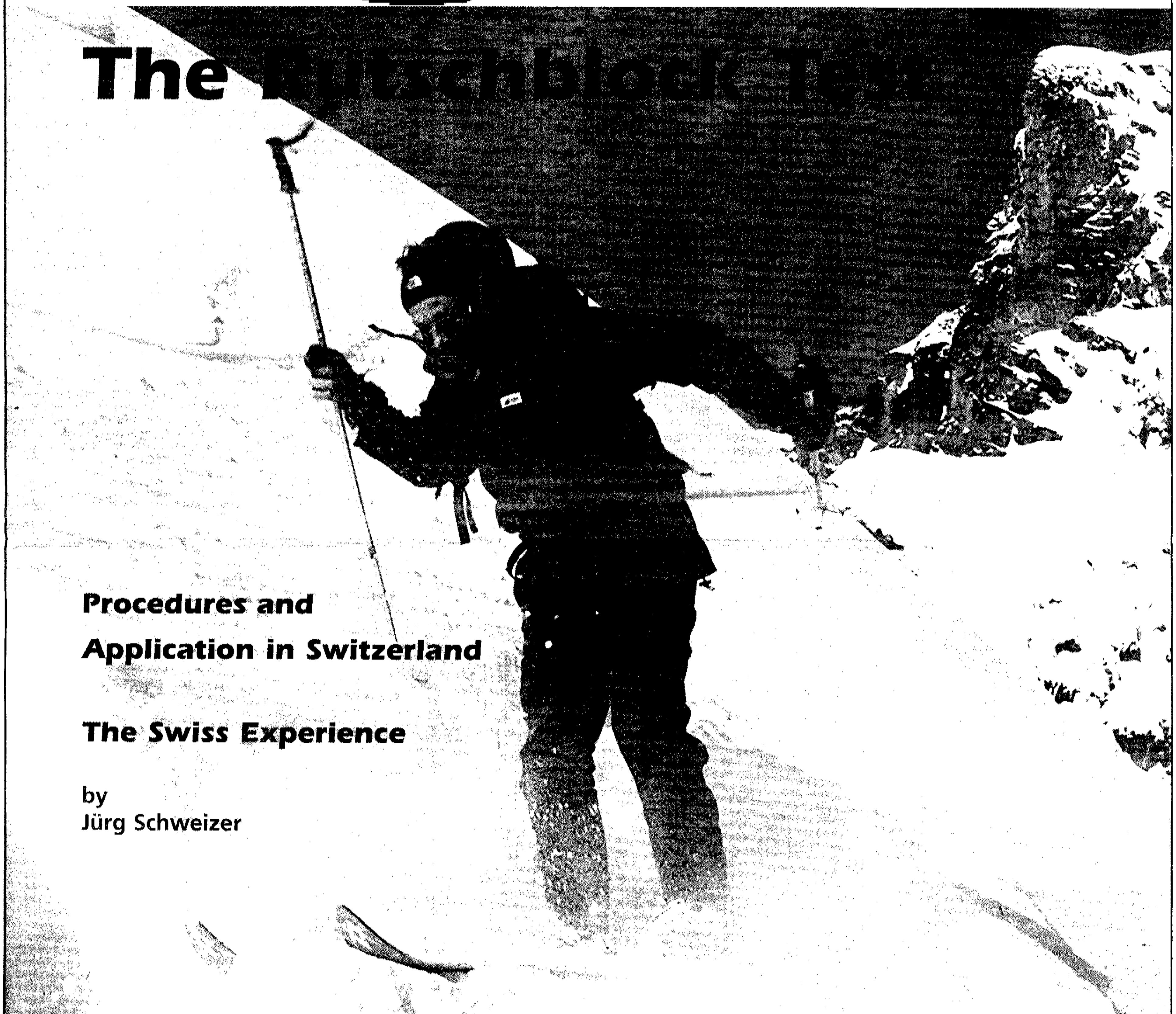
THE Avalanche REVIEW
A Publication of the American Avalanche Association
VOLUME 20, NO. 5
AUGUST 2002 US $4.95
On the web at www.avalanche.org/~aaap

The Rutschblock Test



Procedures and Application in Switzerland

The Swiss Experience

by
Jürg Schweizer

In This Issue

Abstract: *The rutschblock test is one of the most reliable snowpit stability tests. It is a mini slab avalanche that is tested with the appropriate dynamic load: the a skier or snowboarder. The test method and its limitations are reviewed. The application of the rutschblock test as the standard stability test in the observational network of the Swiss Avalanche Warning Service is described.*

Introduction

The rutschblock test was developed in the seventies in Switzerland, established in the eighties by Paul Föhn (Föhn, 1987) and popularised in the form of the a wedge (called a "rutschkeil") by Swiss mountain guide Werner Munter (Munter, 1991), who later on discarded the test. Finally, in the nineties, it was taken to North America, where it was intensively used for field studies and refined by Bruce Jamieson (Jamieson and Johnston, 1993a,b; Jamieson, 1995).

The rutschblock is the test that is best related to human triggering and therefore the best test to find critical weaknesses in the snowpack. It is a true stability test since because it integrates weak layer strength, weak layer depth, slab properties and load characteristics. The sample size is larger compared to other snow stability tests, which makes the rutschblock test more reliable. The test area of $3m^2$ is believed to be larger than the critical

Continued on page 14

Continued from cover.

initial failure area needed for slab release. Therefore, fracture characteristics are likely indicative of fracture propagation potential. The rutschblock test is quantifiable and relatively easy to interpret. However, it is the stability test requiring the most time, though only an additional 10-15 minutes if done in combination with a snow profile – which is highly recommended anyway. As the rutschblock test is essentially a mini slab avalanche, it is also good teaching tool.

Procedure

As for any stability test, site selection is crucial. The test is best done in avalanche starting zones, but can be done on safer, less steep slopes as shallow as 25°. In that case, during loading the smooth wall needs to be observed carefully to detect failures-fractures, since the block will likely not slide. On a slope, the ideal location is where snow distribution is believed to be relatively uniform and snow depth rather below average. Therefore, the location should not be too close to a ridge or crest where the wind strongly influences snow deposition. As the test is best done in avalanche starting zones, it is obvious that the observers need substantial experience in assessing avalanche hazard and in safely travelling in the backcountry, and that standard safety and additional precautionary measures are indispensable. Preferred sites are small slopes with a smooth profile. Of course, slopes with terrain traps, cliffs or large rocks at the bottom of the slope should be avoided. As McClung and Schaerer (1993) state, the principal difficulty in applying the test is finding a slope that is, at the same time, steep enough, sufficiently safe and representative of starting zones.

After choosing a site and taking a snow profile, testers isolate a snow block of 2 m x 1.5 m from the surrounding snow cover. Besides shovels no additional material is needed except a thin cord for cutting the back of the block. The isolated block is then loaded increasingly in five steps (Table 1) by a skier, but it also works if loaded by a snowboarder (Gleason, 1998). The loading steps as given in Table 1 are the ones given by Föhn (1987) and used by avalanche professionals in Switzerland. There exist slight differences in the loading steps (CAA, 1995; Jamieson, 2000; Tremper, 2001) compared to the originally proposed scheme by Föhn (1987). The Canadian procedure (CAA, 1995) is very close to the Swiss one, but takes into account peculiarities of the deep snow country. The interpretation and limitations given below are based on studies done with either the Swiss or Canadian procedure, and accordingly only valid, if these procedures are followed. In view of the overall accuracy of the test, the differences are close to negligible. However, within an observational network, consistent procedures are essential.

During the loading, a second person should carefully watch what is happening. When a fracture occurs, the testers should note or record the fracture depth , the corresponding layer in the snow profile, and the rutschblock score (1 ... 7). The testers should also record and communicate what portion of the block slid (whole block, part of the block [usually below skis], only an edge) and the characteristics of the fracture plane (smooth, rough, irregular) (Tables 2 and 3) (Schweizer et al., 1995; Schweizer and Wiesinger, 2001). This information is considered as important for assessing whether a slab avalanche can occur, i.e. whether fracture propagation is likely. If only part of the block releases this is usually associated with rather stable conditions, whereas the release of the whole block with smooth fracture plane at rutschblock scores 4 to 5 is an indication of triggering potential. It is therefore proposed to formally integrate some shear quality rating into stability test results (Johnson and Birkeland, 2002).

It is important to record not only the rutschblock score but also the type of release and fracture. In this case – which was adjacent to a skier triggered slab avalanche — the whole block did release.

Photos by Jürg Schweizer

During the Rutschblock test, carefully watch the block to detect where it fractures. After the test measure the fracture depth, determine the exact fracture location (e.g. above or below the crust?) and compare it with the snow stratification recorded.

Table 1: Rutschblock loading steps as used in Switzerland

Rutschblock score	Loading step that causes fracture
1	Isolating the block, during digging or sawing
2	Gently approaching or stepping onto the block
3	Pushing downwards by dropping from straight legs to bent knees (weighting)
4	First jump from above with skis/board
5	Second or third jump from above with ski/board
6	Jump from above without skis or board
7	Block does not slide

Table 2: Rutschblock test: release type

Release type: Portion of block that did slide
Whole block
Part of the block (Usually below skis)
Only an edge

Table 3: Rutschblock test: fracture type

Fracture type: Characteristics of fracture plane
Smooth
Rough
Irregular

Interpretation

The rutschblock is relatively easy to interpret. In general, rutschblock scores 1 to 3 are associated with unstable conditions, scores 4 and 5 suggest intermediate snow stability, and scores 6 and 7 indicate relatively stable conditions. The scores are best interpreted as estimates; i.e. possible deviations of ±1 score should be taken into account. False predictions occasionally occur. In the case of low rutschblock scores (1 to 3), false unstable predictions do not cause problems. However, false stable predictions can be fatal, i.e. unstable conditions prevail despite a high rutschblock score (6 or 7). However, it has been shown that the test substantially overestimates snow stability in less than 10% of the cases, for reasonably chosen test sites (Jamieson, 2001). This possibility of false stable predictions is the main reason why decisions about snow stability should never be based solely on a single test result.

Rutschblock test results can easily be communicated, but as pointed out above, should be supplemented by a snow profile. Doing so allows the type and depth of weak layer, slab properties etc. to be considered for the overall stability rating and for extrapolation purposes.

For more thorough interpretation of a snowpit with a rutschblock test, there exists a five-level stability rating scheme that relates snowpack information including the rutschblock score to a stability class (Table 4) (Schweizer and Wiesinger, 2001). This scheme gives a more formal measure of local slope stability, but again, it should be complemented with other measurements and field observations for avalanche danger assessment.

Limitations

The test has some disadvantages and limitations that should be known. Some disadvantages have already been mentioned: exposure to avalanche terrain, relatively time consuming, not foolproof and small chance of false predictions.

The false predictions are mainly the result of snowpack variability. However, snowpack variability does not produce completely random results. It has been shown that if a slope is completely covered with stability tests (Jamieson, 1995), the results are in fact variable but not random. By avoiding obviously disturbed sites, most rutschblock scores can be expected to be within ±1 step of the slope median. So the chance of getting a rutschblock score 5 instead of 3 is very unlikely, provided the observer is experienced in site selection. As the studies by Jamieson (1995) were done on slopes around tree line, it is expected that on slopes in the alpine, above tree line, variability is larger due to more pronounced wind effects.

A general problem of a test giving a quantifiable result in the form of single number is that people tend to overestimate the validity of the test result. Some further limitations to be considered when interpreting rutschblock tests are given below.

- The effect of slope angle on the test result is relatively minor. The rutschblock score tends to increase by 1 for each 10° decrease in slope angle (Jamieson, 1995). However, rather than adjusting the score to a standard slope angle, it is better to report the slope angle with the score.
- The test is, like any stability test, to a certain degree observer dependent. However, it is the stability test for which loading steps are best defined and observer dependence is most limited. The person loading the block should be of standard size, i.e. weighing about 80 kg, including equipment.
- As with any snow stability test, it is recommended only for dry snow conditions, since interpretation becomes difficult and unreliable in moist and especially in wet snow conditions.
- The rutschblock test can not be applied for reliably testing new snow instability, except when ski penetration at the critical loading stage is at least 10 cm less than the weak layer depth.
- In the case of deep weak layers below thick, well-consolidated slabs, the rutschblock score usually underestimates stability since peripheral strength becomes important, and this factor is not considered by the test.
- Finally, as for any stability test, it must be pointed out that it is a point measurement only and definitely not a one-step stability evaluation. Stability evaluation should never be based on one test result only, but should integrate all types of field observations, such as new snow depth, snow transport by wind, temperature, avalanche activity, and whumpfing sounds.

Application

Within the framework of the Swiss Avalanche Warning Service, the rutschblock test is used as the standard snowpit stability test. The interpretation of the many profiles with accompanying rutschblock tests by the warning service has recently been formalised by introducing a stability classification. Each profile is assigned to one of five stability classes. The main criteria are rutschblock score, fracture type and character, existence and type of weak layer, hardness (Figure 1), grain type and size (Schweizer and Wiesinger, 2001 Table 4). The stability derived from the snow profiles is then combined with other observation on snow stability, e.g. avalanche occurrence, and with slab thickness and potential avalanche size and frequency to assess the danger level.

The snowpit snowpack data used for producing the avalanche bulletins comes from three main different sources:

First, snow profiles supplemented with a rutschblock test are performed on a regular basis (several times a week) by the staff of the warning service to assess snow stability, mainly in the Region of Davos. These

Table 4: Snow profile stability rating scheme for dry snow profiles with stability tests.

Note: Not all criteria of a specific class have to be fulfilled and not all have the same importance. Sometimes, of course, profiles fall in-between two classes. In that case, the profile is assigned to the stability class for which the more important criteria are fulfilled; e.g., RB score usually overrules profile type. The Rutschblock score given refers to a test where the whole block did slide on a smooth fracture plane; otherwise, a higher stability class should be considered. For the hardness profile types see Figure 1. The scheme is presently only applicable for dry snow slab avalanches with the skier as trigger in mind. In the spring other parameters have to be considered, as well as for the case of naturally released avalanches (from Schweizer and Wiesinger, 2001).

Class of stability	Description
5: very good	No critical weak layers present. In general well consolidated (ram resistance R larger than about 100 N), some soft layers (new snow or faceted crystals) near the top possible. Faceted crystals in the lower snowpack may be present, but with R>100 N ("4 fingers" or harder). The bottom is usually well consolidated as well, but occasionally a potentially weak base of large faceted crystals or depth hoar may exist, but is covered with a thick cohesive layer (at least 70 cm with R>200 N). Hardness profile type: 4, 6 and 10 Rutschblock score: 6 or 7
4: good	Weak layers may be present, but not very prominent, e.g. showing no clean shear. In general well consolidated middle part with R > 100 N, or prominent hard crust of a few centimetres thickness in the upper third of the snowpack. At the bottom a potentially weak base with large faceted crystals or depth hoar may exist, but is covered with cohesive snow (at least 50 cm with R>100 N) The snowpack might fail if applying high stresses to interfaces or less well-pronounced weak layers, or on top of the depth hoar base. Hardness profile type: 2, 3, 4, and 6; Rutschblock score: 5 or 6
3: fair	Weak layers are present, showing clean shears, but transitional scores (4,5). Weak layers often consist of rounded persistent forms. Some soft layers with R ≈ 40 N present (except new snow on top), but most of the snowpack is well consolidated. Profile type: 2, 3, 4, 8, 9; occ. 7 Rutschblock score: 4 or 5; occ. 3, e.g. when overlain by thick strong slab.
2: poor	Prominent weak layers and/or interfaces are present, showing clean shears. Weak layers of surface hoar or faceted crystals, larger than 1 mm, or interfaces within the new or partly settled snow or new snow on crust. Hardness of slab is R<40 N ("fist" to "4 fingers"). Some well-consolidated parts may exist (R=100...300 N), but the thickness of these layers is less than 30 cm. Hardness profile type: 1, 2, 5, 7, 8 and 9 Rutschblock score: 2 or 3
1: very poor	Prominent weak layers and/or interfaces are present. Thin weak layers of surface hoar or faceted grains, larger than 1-2 mm sandwiched between harder layers, or facets on crusts. The bottom is frequently weak, occasionally covered with only one cohesive slab layer. The ram resistance may be low from top to bottom (R≈20 N). In general, ram resistance above the weak layer is R<50 N, often "fist". There are no hard layers with R>150 N present, crusts are usually thin and do not show up in the ram profile. Hardness profile type: 1, 5, 7 and 9 Rutschblock score: 1 or 2

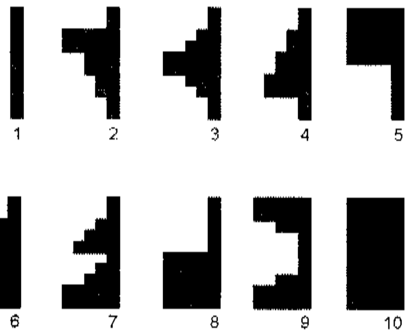


Figure 1

Classification of hardness profiles.

The hardness profile describes how well the snowpack is generally consolidated, and the major changes in hardness with depth. When classifying a hand hardness profile, thin crusts e.g.are usually neglected. The profile type indicates little about the existence of a weak layers, but indicates slab structure, and whether a potential avalanche might sweep out deeper layers which could lead to a much larger avalanche.

The profile types 1-5 all have a weak base, whereas the profile types 6-10 are well consolidated at the bottom. The profile types 1, 4, 7, 8 (occ. 5) are more frequently found in profiles adjacent to skier triggered avalanches, whereas types 2, 3, 6, 10 are usually associated with stable profiles.

Profile type is significant only for profiles from mountains ranges with a snow depth typically less than 2 m. For ranges such as the Columbia Mountains of Canada it is not very useful since the vast majority of profiles are classified as type 6.

(From Schweizer and Wiesinger, 2001; Schweizer and Jamieson, 2002).

snowpit observations provide the observers with the necessary background information on the snowpack development for the daily forecasts. They guarantee that the forecasters have a point of reference when extrapolating to other regions.

Second, in addition to the forecasters, the avalanche warning service's observers also use the rutschblock test on a regular basis. Hence, it is part of the regular observation program. There are about 30 observers spread over the Swiss Alps who do snow profiles and rutschblock tests on slopes above timberline on a bi-weekly basis twice a month. This data is often the most valuable information for the warning service in times of low meteorological activity or at the beginning and end of the season, when many stations in the manual observation network are not yet or no longer running. The profiles with the accompanying test results are transmitted, stored in a database, analysed and represented on a map. The analysis is based on the stability rating scheme. The map can be put on the web, so that the public can get an idea of snow stability throughout the Swiss Alps. To avoid accidents and to ensure test results are representative, training of the observers is crucial. Presently, further steps to improve the training of the observers are under consideration.

Finally, the test is used for research purposes, e.g. for verifying regional stability, studying spatial variability at the regional scale, and verifying new snowpack stability investigation methods. It is the present standard, and is used to improve stability evaluation that is estimated with the help of snow cover models.

Conclusions

The rutschblock test is considered as the most reliable snowpack stability test. It is the standard snowpit test of choice for avalanche professionals in Switzerland and partly in North America, where many professionals prefer quicker tests, such as the stuffblock or compression tests, that can be done several times. The rutschblock test should not be used by recreationists with little experience for decision making because experience is essential for site selection, and interpretation of results and decision-making. The rutschblock is a semi-quantitative measure of local slope stability; it should be complemented with other measurements and field observations for stability evaluation or avalanche danger assessment.

Acknowledgements

I would like to thank Bruce Jamieson and Paul Föhn for many valuable comments that helped to improve the manuscript.

Jürg Schweizer is a senior research scientist at the Swiss Federal Institute for Snow and Avalanche Research SLF in Davos, Switzerland. He has mainly worked on snow mechanics, avalanche formation and avalanche forecasting, focusing on practical applications. Besides his research, he is responsible for the SLF avalanche awareness courses and is frequently an expert witness in court cases on avalanche accidents. He has been a mountaineer and keen backcountry skier for more than 25 years. He has a Ph.D. in glaciology and is a professional member of the AAA.

References

CAA. 1995. Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches. Canadian Avalanche Association, Revelstoke BC, Canada.

Föhn, P.M.B. 1987. The rutschblock as a practical tool for slope stability evaluation. International Association of Hydrological Sciences Publication 162 (Symposium at Davos 1986 Avalanche formation, Movements and Effects), 223-228.

Gleason, A., 1998. A comparison study of the Shredblock and Rutschblock snow stability tests. Proceedings International Snow Science Workshop, Sunriver OR, U.S.A., 27 September-1 October 1998, 249-252.

Jamieson, J.B., and C.D. Johnston. 1993a. Experiences with rutschblocks. Proceedings International Snow Science Workshop, Breckenridge, Colorado, U.S.A., 4-8 October 1992, 150-159.

Jamieson, J.B., and C.D. Johnston, 1993b. Rutschblock precision, technique variations and limitations. J. Glaciol. 39(133): 666-674.

Jamieson, J.B. 1995. Avalanche prediction for persistent snow slabs. Ph.D. Thesis, University of Calgary, Calgary, Alberta, Canada.

Jamieson, J.B. 2001. Backcountry Avalanche Awareness. 7th edition. Canadian Avalanche Association, Revelstoke BC, Canada.

Johnson, R.F. and K.W. Birkeland. 2002. Integrating shear quality into stability test results. Paper to be presented at the International Snow Science Workshop, Penticton BC, Canada, 29 September-4 October 2002.

McClung, D.M., and P. Schaerer. 1993. The Avalanche Handbook. The Mountaineers Book, Seattle WA, U.S.A.

Munter, W. 1991. Neue Lawinenkunde – Ein Leitfaden für die Praxis. Verlag des Schweizer Alpen-Clubs (SAC), Bern, Switzerland.

Schweizer, J., C. Camponovo, C. Fierz and P.M.B. Föhn. 1995. Skier triggered slab avalanche release - some practical implications. In: Sivardière, F. ed. Les apports de la recherché scientifique à la sécurité neige, glace et avalanche. Actes de Colloque. Chamonix, France, 30 mai 3 juin 1995. Association Nationale pour l'Etude de la Neige et des Avalanches (ANENA), Grenoble, France, 309 315.

Schweizer, J. and T. Wiesinger. 2001. Snow profile interpretation for stability evaluation. Cold Reg. Sci. Technol., 33(2-3), 179-188.

Schweizer, J. and J.B. Jamieson. 2002. Contrasting stable and unstable snow profiles with respect to skier loading. Paper to be presented at the International Snow Science Workshop, Penticton BC, Canada, 29 September-4 October 2002.

Schweizer, J., C. Camponovo, C. Fierz and P.M.B. Föhn. 1995. Skier triggered slab avalanche release - some practical implications. In: Sivardière, F. ed. Les apports de la recherché scientifique à la sécurité neige, glace et avalanche. Actes de Colloque. Chamonix, France, 30 mai-3 juin 1995. Association Nationale pour l'Etude de la Neige et des Avalanches (ANENA), Grenoble, France, 309-315.

Tremper, B. 2001. Staying Alive in Avalanche Terrain. The Mountaineers Books, Seattle WA, U.S.A.Table 4

At the loading steps 4 and 5, jump from above. If the slab is very soft, it can be more appropriate to jump on the compacted spot, i.e. following the Canadian procedure.
Photo: Bruce Jamieson

In this example a minor part of the block released after the first jump from above (RB score 4). However, the fracture surface was smooth.
Photo: Jürg Schweizer

(Cover photo) The Rutschblock is a mini slab avalanche: 2 m (across slope) times 1.5 m (upslope). It is essential to stick to these dimensions, so that the area tested is always the same. Also, the column needs to be fully isolated, i.e. *you have to cut the back of the block.*
Photo: Jürg Schweizer