The Avalanche Review, VOL. 7, NO. 6, MARCH 1989

The "Rutschblock" as a Practical Tool for Slope Stability Evaluation

by Paul M.B. Fohn

INTRODUCTION

The "Rutschblock" test - or as it named also: Swiss test, jump test, or wedge test-may be viewed as a special form of ski testing. It was first used in the Swiss Army in the sixties to exhibit weak layers in the snowpack. During the following years it gradually became a tool for slope stability evaluation, mainly promoted by Munter (1973). Because initially there was no proper calibration for this test, we decided to calibrate this method against others (stability index approach, avalanche observation program SFISAR). For this purpose concurrent data on seven "Rutschblock" degrees,which are defined later - measured stability indices and adjacent avalanche activities were collected during six winters (1980/81-1985/86).

TEST CALIBRATION

After selecting a representative, appropriate slope with an inclination of at least 30 degrees, a small retangular slab (2m x 1.5m = 3m squared) is exposed by digging out three sides: both flanks and the bottom edge (i.e., Stauchwall). The fourth side, the crown flank, is separated by sawing with a cord as shown in Fig. 1. The latter mainly is important if the top layers are hard serving as tension anchors. The trenches at the sides and the bottom must be at least as deep as the suspected weak layers or interfaces of the snowpack. The bottom trench, which is dug out first, may be used as a snowpit, where all other observations such as stratigraphy and hardness are made. It is essential not to disturb the snow inside the slab and to dig outwards from the prefixed slab limits. The digging work takes usually 20 to 30 minutes if snow depth is 11.5m. Some prefer to cut out a wedge-shaped block of equal area, avoiding to dig the flank trenches.

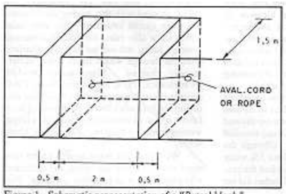

Figure 1. *Schematic representation of a "Rutschblock."*

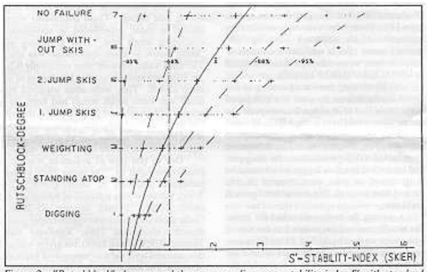

Figure 2. *"Rutschblock" degrees and the corresponding mean stability index S' with standard deviations.*

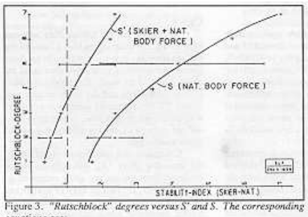

Figure 3. *"Rutschblock" degrees versus S' and S. The corresponding equations are:*
$Y = 2.52 + 5.91\, S'^{1/2}$ and
$Y = 4.43 + 4.57\, S^{1/2}$

TEST PERFORMANCE

The trigger mechanism for fracturing the small slab is a skier; therefore in the "Rutschblock" test we check the shear strength of the snow layers or interfaces exactly with the same mean as in reality. The main difference is that the real potential snow slab is supported in addition by upper end tension and lower end pressure forces together with multilayer shear forces at the slab flanks.

In order to save time, stresses are applied in progressive levels. These levels (degrees) are:

1. The act of digging or sawing out the slab.

2. Gently approaching on skis the top of the slab from above and standing atop the slab, skis spanning the gap between the two flank trenches.

3. Weighting of skis, but no jump (compaction of surface layers).

4. Jumping a flying leap onto the upper edge of the slab.

5. Jumping a second time onto the same compacted spot.

6. Jumping without skis, intensifying the stress peak.

7. None of the previous actions produced clean failures.

The ease with which slab layers break serves as indicator of how poorly the layers are bonded. It may be compared or calibrated with other stability evaluation methods.

CALIBRATION

Roughly 150 "Rutschblock" test results collected over six winters, mainly in the neighborhood of Weissluh joch, were compared with concurrent shear frame measurements and calculated stability indices. The extended stability index approach, containing an index S for natural slab releases and an index S' for artificially triggered slabs is described in detail in another paper of this Symposium series (cf. Fohn, 1987). Therefore only the comparative results arc presented here. The measured shear frame data (O.5m squared) were corrected for size effects and overburden pressure. Fig. 2 shows the data points and the calibration curve connecting the mean values (X) of S' for each "Rutschblock" level or degree. Additionally the simple SD and the twofold standard deviation are also represented. Despite a large scatter of data points a relation of the form:

Y=a+bS''R can be established. Y signifies the "Rutsch block" degree and a = -2.52, b = 5.91.

The calibration curve shows that the first three "Rutschblock" degrees occur mostly at stability levels S' less than one. If these degrees are ascertained on a given day, slopes of similar aspect, altitude and inclination must be considered as dangerous.

The same "Rutschblock" test-series has also been compared with the usual stability index S, taken as the ratio between shear strength and natural body stress in the weakest sublayer. The mean values of S' and S and the standard deviations are represented on Fig. 3. The mean values of S are clearly larger than those of S', i.e., the probability of natural slab releases is two to three times smaller than the probability for slabs triggered by skiers at a given "Rutschblock" degree.

In order to derive for each degree the probability of population values S' 1, the sample values were approximated by a normal distribution. By calculating the area covered left to one with standardized methods, this probability was estimated. The values are shown on Fig. 4, curve 1. In similar manner this probability has been calculated by non-parametric methods (curve 2). This procedure is based on "rank" assumptions. Finally the assessment of the relative frequency of concurrent avalanches yields curve 3. All three curves show clearly that the probability of failures decreases substantially with increasing "Rutschblock" degree, but that even at high degrees this probability unfortunately does not drop to zero. The main reason for this is the large data-variance, which may be attributed to imprecision in site selection. The selection of representative spots requires experience and sometimes audacity. Safe positions near ridge crests or places surrounded by large boulders are seldom suitable.

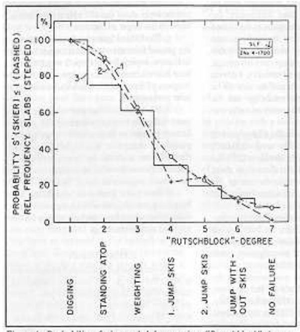

Figure 4. *Probability of triggered slabs at a given "Rutschblock" degree.*
-- Gaussian assumption
··· non-parametric assumption
— concurrent avalanching

CONCLUSION

The "Rutschblock" test is a useful tool for slope stability evaluation, but it is not foolproof. Improper site selection causes inaccurate test results, which are misleading (resulting in overestimation of the stability indices) and hence dangerous. The method is restricted to experienced persons with an intuitive feel for the slope stability distribution. It has to be supplemented by other methods such as snow-profile evaluations, analysis of meteorological parameters, etc., as described by Perla and Martinelli (1976) and Salm (1982).

As a general conclusion:

· when degrees 1-3 are observed, one has to suspect numerous spots with unstable snowpack on similar slopes: a dangerous situation.

· when degrees 4 or 5 are observed, some local instabilities may be expected on similar slopes: a suspicious situation. Use of other methods and proper route selection are essential.

· when degrees 6 or 7 are observed, there is a low risk of triggering snow slabs on similar slopes; however, basic precautions should be taken.

One must always keep in mind that failure strength of weak layers has a statistical aspect to it which can cause substantial variations on the same slope. The scatter in the test data given in this paper provide an estimate of that effect. However, the comparatively large test area of a Rutschblock (3 square meters) guarantees that the usual size effect known from shear frame measurements plays a minor role for practical applications.

ACKNOWLEDGEMENTS

I would like to thank Dr. C. Jaccard for the non-parametric analysis of the data set and Dr. B. Salm and R. Meister for helpful discussions. *Additionally I* would like to thank the following collaborators for field work assistance: B. Beer, E. Beck, H.J. Etter, S. Gliott, B. Heinzer, R. Meister, J. Kindschi, J. Planta, B. Regli, Th. Reinhard, W. Zierhofer. The winter mountaineering group of the Alpine Club of Switzerland under the leadership of mountain guide W. Munter provided stimulating discussion and criticism which improved the paper.

REFERENCES

Fohn, Paul M.B. (1987). The stability index and various triggering mechanisms. Intemat. Symposium on Aval. Formation, Movement and Effects, Davos, Sept. 1986. IAHS Publ. No. 162.

Muntcr, W. (1973). Kleine Schnee- and Lawincnkunde. Skifiihrer in "Alpinismus," Heft 1, 1973, Heering-Verlag, Miinchen, 32 pp.

Perla, R.I. & Martinelli, M. Jr. (1976). Avalanche Handbook, USDA Forest Service, Fort Collins, Colorado, Agriculture Handbook 489, 238 pp.

Salm, B. (1982). Lawinenkunde fur den Praktiker, Verlag Schweizer Alpen-Club, Bern, 148 pp.

The Avalanche Review, VOL. 7, NO. 6, MARCH 1989