

Rough Correlations of Common Snowpack Stability Tests

—Mark Moore¹

ABSTRACT: Because each different layer of snow can respond to applied stress in a variety of ways, and because the mechanical properties of snow layers often change dramatically over space and time, it is difficult if not impossible for one simple mechanical test to determine whether or not a slope can avalanche. Often this can only be definitively answered by actually skiing, riding, hiking, climbing or boarding the slope in question—which is not recommended as a mechanical test except in the context of slope cuts or ski testing, preferably on small safe(r) slopes. However, there are a variety of simple field tests available that can safely aid in the stability analysis process, and these include the Rutschblock, Stuffblock, Compression (or tap) Test, and Shovel Shear. When these tests are used in combination with all the other snowpack, weather and terrain factors out there—and when they are repeated often enough to appropriately sample the spatial and temporal variability of snow—then they can help to determine avalanche potential and promote safe travel.

For practical purposes in many applications, common snowpack stability tests can be categorized into three basic stability levels. In addition to the internationally accepted test descriptors and classifications, these levels can be approximated in the Red-Yellow-Green or GO / NO GO rating system (Fesler and Fredston, 1994²) that gives **rough** correlations between various tests and the estimated stability level(s) of red (NO-GO) yellow (Caution) or green (GO):

- Red light (No Go) — another time, another day or try another place
- Yellow Light (Caution) — be conservative, more tests recommended
- Green Light (Go) — proceed, but don't stop thinking and updating

Be aware that the strength test table below provides ROUGH test correlations, and proper application involves practice and consideration of all factors in the data triangle (snowpack, weather, terrain and the human factor).

Useful snow stability information is hardly ever derived from just one test or one snowpit. It involves a process—an evolution of stability assessment—with snow profiles and strength tests being just one component. Avalanche potential is part of a strength-energy-structure continuum, and stability tests relate primarily to the strength portion. Hence other important considerations include knowledge about snowpack energy (related to the shear or fracture quality of stability tests) and snowpack structure (McCammon and Schweizer, 2002³). Accident research has shown that human triggered avalanches occasionally occur with stability (Rutschblock) scores of 6 and 7 and an apparent Green/Go rating level. In these events, consideration of other instability indicators such as poor structure (more lemons) or more available energy (high quality shears) can be essential in helping to avoid or mitigate avalanche danger.

Keywords: stability test, snowpack strength, avalanche danger, snowpack structure, snow profile, shear test

Please note that the author is extremely interested in input and feedback regarding the strength test correlations given in Tables 1 and 3 below. Please send your comments to the email or address listed below.

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² Fesler, Doug and J.A. Fredston, Snow Sense, Alaska Mountain Safety Center, Anchorage, AK, 1994.

³ McCammon, I. and Jürg Schweizer. 2002. [A field method for identifying structural weaknesses in the snowpack](#). *Proceedings of the 2002 International Snow Science Workshop*, Penticton, BC, Canada, 477-481

Table 1. Rough Comparison of Common Snowpack Tests

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Meaning/ Stability	Numeric rating	Common rating	<u>Type of Test</u>			
			----- Strength -----		---Shear---	
		(Abbreviation)	Rutschblock RB	Compression CT	Stuff block SB	Shovel shear ST
Unstable (similar slopes may fracture when skied)	1 Red	Collapse (C)	Fractures when isolating block	Fractures when isolating column or laying shovel on column	Clean shear while isolating column or with weight of sack	Block settles when cut
			RB1	CTC	SBC	STC
Unstable	2 Red	Very Easy (V)	Fractures approaching or stepping on block	1-6 taps (articulate from wrist)	Fractures cleanly with weight dropped from 10 cm (4 in.)	Fractures cleanly during cutting or insertion
			RB2	CTV	SBV	STV
Unstable	3 Red	Easy (E)	Fractures with sharp knee bend / unweight	7-12 (wrist + elbow)	Fractures with weight dropped from 20 cm (8 in.)	Fractures with minimum pressure
			RB3	CTE	SBE	STE
Fair or Marginal (marginally stable)	4 Yellow	Moderate (M)	One jump (large)	13-18 (elbow)	Fractures with weight dropped from 30 cm (12 in.)	Fractures with moderate pressure
			RB4	CTM	SBM	STM
Fair or Marginal	5 Yellow	Moderate to Hard (MH)	A second jump (large)	19-24 (elbow + arm)	Fractures with weight dropped from 40 or 50 cm (16 or 20 in.)	Fractures irregularly with moderate pressure
			RB5	CTMH	SBMH	STMH
More stable (lower potential for triggering)	6 Green	Hard (H)	Jump ½ way down or multiple large jumps	25-30 (arm)	Fractures with weight dropped >50 cm (>20 in.)	Fractures after firm, sustained pressure
			RB6	CTH	SBH	STH
More stable	7 Green	No fracture (N)	No fracture	No fracture	No fracture	No fracture
			RB7	CTN	SBN	STN

In the rough guideline meanings above:

- **Unstable** indicates that avalanche slopes with similar conditions (including aspect and slope angle) are likely to be triggered by a skier; recreating here might best be considered on another day or another time, or try another place
- **Fair or Marginal** indicates marginally stable conditions (skier triggered slab releases are possible and more tests are indicated to assess stability; conservative route selection is recommended)
- **More Stable** indicates a low (but not negligible) potential of a skier-triggered avalanche on a similar slope; proceed, but don't stop thinking and updating

Table 2. Comments on Tests

Test	<i>Comments</i>
General	<ul style="list-style-type: none"> • All tests need repeatability to increase confidence in results; • Note slope angle and aspect; • Most tests decrease/increase 1 level for each 10 degree increase / decrease in slope angle; • Quality of shear [1-clean and fast (paper), 2-normal (scissors), 3-uneven & irregular (rock)] is important to note and apply to test interpretation—see below • Need to identify weak layers and try to correlate with past weather to estimate aerial distribution (local vs widespread) • Always consider these strength results along with all other snowpack, weather and terrain information, including structural pattern and energy information
Rutschblock (RB)	<ul style="list-style-type: none"> • Limited to upper 1 m of snowpack; • Not for deeply buried weak layers; • Normal size 1.5m upslope x 2 m across slope, slightly angled in at top; • Must cut back wall to be meaningful as Rutschblock or else notate; • Size and orientation may be modified for boarders, snowshoers and snowmobiles—note this change in shape under comments; • Roughly related to red light (RB1-3), yellow light (RB4-5) and green light (RB6-7) conditions • May not be representative or meaningful for hard near-surface crusts, hard slabs or more deeply buried persistent weak layers (e.g., surface hoar, faceted grains)
Compression (CT)	<ul style="list-style-type: none"> • Limited to upper 1.2 m (120cm) of snowpack; • Good correlation with Rutschblock; • Average decrease of 1.1 taps for each 10 deg increase in slope angle (varies from 0.2-3); • Good for new snow instability; • Quantifiable—normally more consistently repeatable results than shovel shear • Rough correlation with red light (1-12), yellow light (13-24) and green light (≥ 25 taps) conditions • Results may vary between testers and force applied
Shovel Shear (ST)	<ul style="list-style-type: none"> • Small sample size—need repeatable results • Size normally ~30x30 cm—25x25 cm okay and little effect; • Shape and size of shovel has limited effect; • Location and strength of layers only—not a stability test; • Use care not to lever column; • Better than compression for old snow and buried weak layers > 100-120 cm deep
Stuff block (SB)	<ul style="list-style-type: none"> • Small sample size—need repeatable results; • Size 30 x 30 cm; weight of 4.5kg (10 lbs); • Quantifiable results like compression test; • Results approximate Rutschblock scores • Works best with near surface / new snow instability
Loaded column (LC)	<ul style="list-style-type: none"> • Small sample size—need repeatable results; • Quantifiable results like compression test, but difficult to gage quantity (snow density) of loading applied

A simplified Field Version of Table 1 is shown below. This preliminary and very rough correlation guide is presented as a possible tool for comparing and applying field tests results only if energy and structure information (see Figure 1 below and the ISSW06 paper for more detail and other references) is part of the stability assessment.

Table 3. Simplified Strength Test Correlations

Simplified Strength Test Correlations

[Moore, 2006 — www.nwac.us/education]

Test	Rutschblock	Compression / tap	Stuffblock	Shovel
Stability				
More unstable	RB≤3	CT ≤12	SB ≤20	ST ≤E
Marginally stable	RB4-5	CT13-24	SB30-40	STM-MH
More stable	RB6-7	CT≥25	SB ≥50	ST ≥H

Structure [lemons ≥4 help concentrate stresses]:

- Depth of fracture plane** (≤1m)
- Weak layer thickness** (≤ 10cm)
- Hardness change across fracture plane** (≥1 step)
- Persistent grain type** (facets, surface or depth hoar)
- Grain size change at fracture plane** (≥1.0 mm)

Shear Quality [nature of the fracture]

- Q1— Unusually clean, planar, smooth and fast shear surface:** weak layer may collapse during fracture and slab may slide into pit on slopes angles > 35°
- Q2— "Average" shear, mostly smooth,** but slab does not slide as readily as Q1; fracture occurs throughout most of slab but some small irregularities possible—not as many as Q3
- Q3— non-planar shear surface, uneven, irregular and rough:** shear fracture typically not through the whole slab / weak layer interface. Slab may experience only slight movement

Shear Quality (Q)— the “nature” of the fracture

As mentioned in the general comments section of the above table, the quality of the shear tells a great deal about the bonding at the shear plane. An irregular shear surface indicates some bonding and strengthening has begun between layers, while a clean shear surface indicates a weak attachment between snow layers. In either instance, it is common practice to examine and try to identify snow grains scraped from either the bottom of the block that failed or from the top of the bed surface or weak layer remnants left behind. Noting the Shear Quality (Q1, Q2 or Q3) when recording stability test results can give important information about the presence and persistence of suspected weak layers, as smooth fast shears often indicate surface hoar or very weak bonding to a smooth bed surface (like a rain crust or ice lens)—weakness that may last awhile. [Note that a more stable test number (e.g., higher Rutschblock) combined with a Quality 1 shear may often be more important than a less stable test number (e.g., lower Rutschblock) with a low Quality 3 shear, since the weak layer or bonding of the potential slab is really what is most important.] The following list gives a brief description of shear quality and its field interpretation. See the [Johnson and Birkeland, 2002](#)⁴ for a more complete analysis of shear quality.

- **Q1— Unusually clean, planar, smooth and fast shear surface;** weak layer may collapse during fracture and slab may slide into pit on slope angles > 35°
- **Q2— "Average" shear, mostly smooth** but slab does not slide as readily as Q1; fracture occurs throughout most of slab but some small irregularities possible—not as many as Q3
- **Q3— non-planar shear surface, uneven, irregular and rough;** shear fracture typically not through the whole slab/weak layer interface. Slab may experience only slight movement

⁴ Johnson, R.F. and K.W. Birkeland. 2002. [Integrating shear quality into stability test results](#). *Proceedings of the 2002 International Snow Science Workshop*, Penticton, BC, Canada 508-513.

Recent snowpack stability research by McCammon and Schweizer (2002)⁵, Jamieson and Schweizer (2003)⁶, Johnson and Birkeland (2002)⁷, and Jamieson, Fierz & Schweizer (2004)⁸ stress that the most reliable snow stability information may result from consideration of more than just strength test results. Indeed, it appears that careful consideration of information from three primary snowpack properties—structure, strength and energy—seems likely to give the most meaningful safety knowledge, as combining all three factors of the snowpack may help to overcome effects of spatial variability and minimize chances of “false stable” results (McCammon and Sharaf, 2005)⁹. Structure, strength and energy may all be viewed as pieces of the “snow stability pie” (Figure 1), with each piece contributing to the overall stability of a particular slope or snowpack.

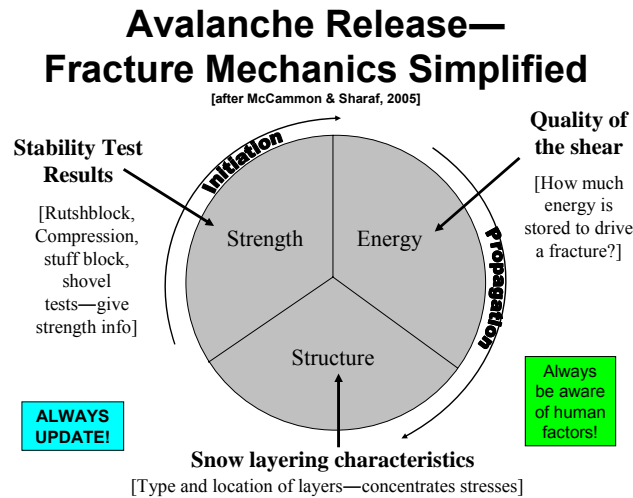


Figure 1. Primary snowpack components affecting avalanche release. Adapted from McCammon & Sharaf, 2005

⁵ McCammon, I. and Jürg Schweizer. 2002. [A field method for identifying structural weaknesses in the snowpack.](#) *Proceedings of the 2002 International Snow Science Workshop*, Penticton, BC, Canada, 477-481

⁶ Jamieson, B. and J. Schweizer. 2005. [Using a checklist to assess manual snow profiles.](#) (yellow flags) *Avalanche News 72*, Canadian Avalanche Association, Revelstoke, BC., 62-71.

⁷ Johnson, R.F. and K.W. Birkeland. 2002. [Integrating shear quality into stability test results.](#) *Proceedings of the 2002 International Snow Science Workshop*, Penticton, BC, Canada, 508-513.

⁸ Schweizer, J., Fierz, C., Jamieson, B. 2004. [Assessing the probability of skier triggering from snow layer properties.](#) *Proceedings of the 2004 International Snow Science Workshop*, Jackson Hole, Wyoming. USDA Forest Service, Fort Collins, CO, 192-198.

⁹ McCammon, I and Don Sharaf, 2005. Integrating strength, energy and structure into stability decisions, *Avalanche Review*, 23 (3): 18–19.