The Compression Test

by Cam Campbell

Site selection

Above all, test sites need to be safe, which means at the top of small slopes with no terrain traps. They need to be representative of the avalanche terrain under consideration (i.e. to gain information about a wind-loaded slope, find a safe and undisturbed part of a similarly loaded slope for the test). They also need to be undisturbed (i.e. the site should not contain buried ski tracks, avalanche deposits, etc., or be within about 5 m of trees where buried layers might have been disturbed by clumps of snow that have fallen from branches). Compression tests can be performed on slopes of any angle, including flat terrain, however care must be taken to observe fractures on low-angled slopes where the slab doesn't slide.

Procedure

The Canadian Avalanche Association's Observation Guidelines and Recording Standards for Weather, Snowpack and Avalanches (CAA, 2007) recommends the following procedure:

1. Isolate a 30 cm x 30 cm column of snow deep enough to expose potential weak layers on the smooth walls of the column (Figure 1). The uphill dimension is measured slope-parallel. A depth of 100-120 cm is usually sufficient since the compression test rarely produces fractures in deeper weak layers. Also, taller columns tend to wobble during tapping, potentially producing misleading results for deep weak layers.
2. Rate any fractures that occur while isolating the column as very easy (Table 1).
3. Place a shovel blade on top of the column (Figure 1). Tap 10 times with fingertips, moving hand from wrist, and rate any fractures as easy (Table 1)).
4. If the snow surface slopes, remove a wedge of snow to level the top of the column.
5. If, during tapping, the upper part of the column slides off or no longer "evenly" supports further tapping on the column, remove the damaged part of the column, level the new top of the column and continue tapping.
6. Do not remove the portion of the column above a fractured weak layer, provided that it evenly supports further tapping, since further tapping may cause fractures in shallower weak layers.
7. Tap 10 times with the fingertips or knuckles moving forearm from the elbow, and rate any fracture as moderate (Table 1). While moderate taps should be harder than easy taps, they should not be as hard as one can reasonably tap with the knuckles.
8. Finally, hit the shovel blade moving arm from the shoulder 10 times with open hand or fist and rate any fractures as hard (Table 1). If the moderate taps were too hard, the operator will often try to hit the shovel with even more force for the hard taps - and may hurt his or her hand.
9. Rate any identified weak layers that did not fracture as no fracture (Table 1).

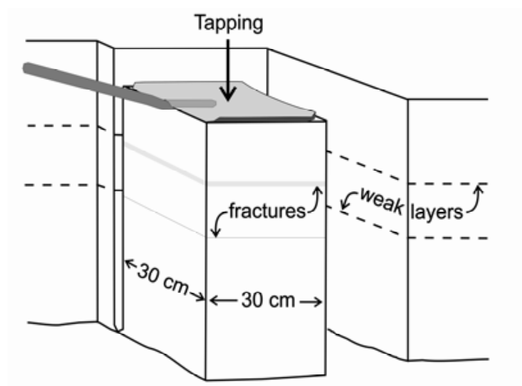

Figure 1 - Compression test technique and column dimensions (CAA, 2007).

Table 1 – Description of compression test loading steps (CAA, 2007).

Term	Description
Very easy	Fractures during cutting.
Easy	Fractures before 10 light taps using finger tips only.
Moderate	Fractures before 10 moderate taps from elbow using finger tips.
Hard	Fractures before 10 firm taps from whole arm using palm or fist.
No fracture	Does not fracture.

The compression test may not produce useful results for weak layers that are very close to the snow surface as thin soft slabs tend to be crushed by the easy taps. A shovel tilt, or burp, test may be useful here. This involves balancing a shovel-blade-sized block of snow vertically on your shovel and tapping, or burping, the underside of the blade.

Fracture character

Fracture character is often difficult to observe. To make it easier, the front face and side walls of the test column should be as smooth as possible. The observer should be positioned in such a way that one side wall and the entire front face of the test column can be observed and attention ould be focused on weak layers or interfaces that are likely to fracture. For tests on low-angled terrain that produced planar fractures, it may be useful to slide the two fracture surfaces across one another by carefully grasping the two sides of the block and pulling while noting the resistance (CAA, 2007). Characterize the fracture according to Table 2.

Interpretation

Figure 2 shows that as the number of taps increases, the likelihood of skier-triggering the same slope decreases. These data were collected by performing two to four adjacent compression tests at representative sites on slopes that were skier-tested and averaging the taps for the primary weak layer. Irregular or indistinct results were not counted, only clean and planar. The compression test isn't perfect. If it was, 100% of the slopes with easy compression test results would have been skier-triggered. Although it is promising to note that none of the slopes for which the compression tests produced no failures were skier-triggered.

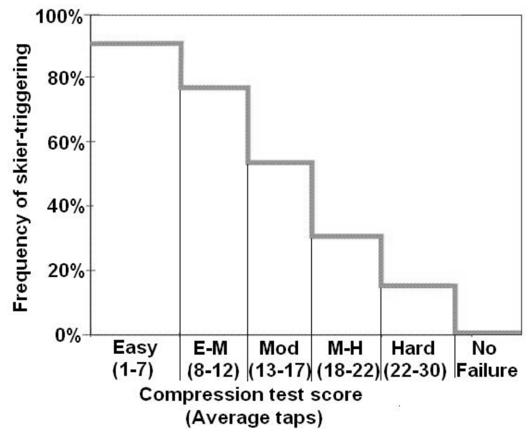

Figure 2 - Frequency of skier-triggering versus compression test score and the average number of taps on slopes that were ski-tested. The average number of taps was calculated from results of 2-4 adjacent tests (Applied Snow and Avalanche Research, University of Calgary data).

Table 2 – Fracture character classification system (CAA, 2007)

Major class	Sub class	Fracture characteristics
Sudden *(pops and drops)*	Sudden planar *(pop, clean and fast fracture)*	A thin planar* fracture suddenly crosses column in one loading step AND the block slides easily** on the weak layer.
	Sudden collapse *(drop)*	Fracture crosses the column with a single loading step and is associated with a noticeable collapse of the weak layer.
Resistant *(others)*	Progressive compression (step by step "squashing" of a layer)	A fracture of noticeable thickness (non-planar fractures often greater than 1 cm), which usually crosses the column with a single loading step, followed by step-by-step compression of the layer with subsequent loading steps.
	Resistant planar	Planar or mostly planar fracture that requires more than one loading step to cross column and/or the block does NOT slide easily** on the weak layer.
Break *(others)*	Non-planar break	Non-planar, irregular fracture.

Note: ** "Planar" based on straight fracture lines on front and side walls of column.*

** Block slides off column on steep slopes. On low-angle slopes, hold sides of the block and note resistance to sliding.

On seemingly uniform slopes, compression test results can vary significantly within a metre or two. One way to reduce the uncertainty associated with this spatial variability of has already been mentioned: if you're going to do compression tests, do at least two and average the taps for a specific layer. Secondly, only rely on the score (very easy, easy, moderate, hard or no fracture) and don't get caught up with the actual number of taps.

Finally, by incorporating fracture character observations into compression test results, not only are we reducing the uncertainty associated with spatial variability but we are also improving the interpretation (van Herwijnen, 2005). Sudden fractures that "pop" or "drop" are more often associated with dry slab avalanches. Hard fractures that "pop" or "drop" should be interpreted with much less certainty than other characters.

References

Canadian Avalanche Association (CAA). 2007. *Observation guidelines and recording standards for weather, snowpack and avalanches*. Canadian Avalanche Association, Revalstoke, BC, Canada.

van Herwijnen, A.F.G. 2005. Fractures in weak snowpack layers in relation to slab avalanche release. PhD thesis. Dept. of Civil Engineering, University of Calgary, Calgary, Alberta, Canada.