Snowpack Part III

Stability Evaluation and Keeping Field Notes

Credits

We have drawn on and synthesized ideas shared by all the avalanche instructors we have worked with over the last 30+ years in these handouts, but Doug Fesler, Jill Fredston, Janet Kellam, Ian McCammon, Lynne Wolfe, and Don Sharaf deserve special credit for some of the best ideas we have used and expanded on here, and discussion with all of them has contributed immeasurably to the development of these ideas.

Summary of Key Points

Snowpack - A Road Map for Stability Evaluation

Stability evaluation has three components:

1. Observations.
2. Traveling tests.
3. Snowpits.

Stability 1, Observations - Obvious Signs of Instability

1. avalanche activity - Recent activity is the clearest indicator of instability!
2. whoomphing or collapsing
3. hollow sounds
4. shooting cracks
5. recent heavy snow
6. wind loading
7. rain or thaw

Stability 2, Slope and Traveling Tests

- Slope Cuts - ski, board, or bank cuts, jump tests, and trundling rocks or cornices.
- Drift and Cornice Tests.
- Switchback Test - Try to cause fracture at switchback by kicking at the wedge of snow it creates, especially useful for new or windloaded snow.
- Parallel Tracks Test - Try to cause fracture by cutting one track above another, especially useful for new or windloaded snow. Bounce or kick to increase shear force on test snow.
- Probing - arm, ski pole, probe.
- Potato Chip Test (PCT).
- Hand Shear, Hand Shear or Ski Pole Block.
- No Excuse Block (NE).

Stability 3, Snowpits - The Quick Pit Chant

1. Pick a representative site using factors: angle, loading, aspect, elevation, RISK.
2. Set up for block tests.
3. Dig it.
4. Smooth it.
5. Brush it.

6. Poke it.
7. Predict it.
8. Shear it.
9. Move on.

Stability 3, Snowpits - Lemons (4 or 5 lemons correspond to weak structure)

- Weak layer depth ≤ 1m.
- Weak layer thickness ≤ 10 cm.
- Weak layer grains - persistent.
- Hardness difference ≥ 1 step.
- Grain size difference ≥ 1 mm.

Stability 3, Snowpits - Yellow Flags (4 or 5 flags correspond to weak structure)

- Weak Layer Grain Size >1 mm
- Weak Layer Hardness < 1Finger
- Weak Layer Grains Persistent
- Interface Grain Size Difference > 0.5 mm
- Interface Hardness Difference >1 Step
- Interface 20-85cm Deep

Stability 3, Snowpits - Shear quality index

Q1 - clean and fast shear
Q2 - average shear
Q3 - irregular or incomplete shear

Stability 3, Snowpits - Fracture Character

SDN - Sudden Fractures
  SP - Sudden Planar
  SC - Sudden Collapse
RES - Resistant Fractures
  PC - Progressive Compression
  RP - Resistant Planar

Stability 3, Snowpits - Most useful tests

- AK Block
- Tap Compression Test
- Rutschblock
- Jump Test
- Potato Chip Test
- Extended Column Test
- Propagation Saw Test

The Old Roadmap - Classical Mechanics Recipe for a Slab Avalanche (layers + gravity)

1. slab
2. weak layer (or poor bonding)
3. bed (or thick weak layer, distinct bed optional, but useful)
4. stress-strength balance
5. stored elastic energy

A Better Roadmap - Fracture Mechanics

1. Strength.
2. Stress.
3. Elastic energy.

4. Structure.

A Better Roadmap - The Stability Wheel (+, 0, or -)

1. Stress/strength balance:
   - Block tests and observations (weakest layer, how weak, depth, and distribution).
   - Loading amount and rate, based on observations.
2. Elastic energy
   - Shear quality (Q scores).
   - Shooting cracks.
   - Propagation in tests.
3. Structure
   - Potato Chip Tests.
   - Lemons & yellow flags (slab, weak layer, & bed).
   - Propagation in tests.

Decision-making/Observation Frameworks - ALP TRUTH

A - avalanches, in the area in the last 48 hours.
L - loading, by snow, wind, or rain in the last 48 hours.
P - path, identifiable by a novice.
T - terrain trap, gullies, trees, cliffs, or other features that increase the consequences.
R - rating, considerable or higher hazard on the current avalanche advisory.
U - unstable snow, collapsing, cracking, hollow snow, or other signs of instability.
TH - thaw, recent warming due to sun, rain, or warm air.

Snowpack - Evaluating Snow Stability

The "Defense of Helm's Deep" Analogy

Our castle of avalanche defenses needs three walls because we know, as in the second book of Tolkien's trilogy, that the avalanche orcs will make it through the first and second walls, and sometimes the third one too.

1. Stability evaluation is the outer wall. Use it all you can, but remember that it **will** be breached eventually. No one is immune, even the best avalanche specialists sometimes blow their stability evaluation.
2. The second wall is our risk management practices: rituals, traveling one at a time, route selection, preparation, training, companion choice, decision-making, evaluation of consequences, and so on. This wall is the one most likely to save us.
3. The innermost keep of the avalanche defense castle is rescue skills, but paradoxically, it is not your own skills that will help you when you are the one who is buried. When you can't rescue yourself, let alone move, it is your friends' skills that will be Gandalf the wizard charging in on a shining steed to save you. Be sure your personal Gandalfs are always well trained and drilled!

Spatial Variability

- This is why evaluating snow stability is not a simple engineering problem. Snow is highly nonuniform, and in fact slab release is dependent on its non-uniformity. Fracture initiates in weak zones, or tender spots, and spreads from them into stronger snow.
- The most effective test procedure is a targeted search for instability, but even so the weak spots are hard to find, as they are hidden under the overlying snow. The weak zones are important to stability evaluation, the average strength is not.
- Snow profiles and block tests are valuable tools, but they alone are not adequate for stability evaluation. You must rely more on observations and slope tests, supplemented by your pit data.

Self-organizing Critical Systems
Snow avalanches exhibit many of the characteristics of self-organizing critical systems, as do many other natural phenomena. The overall behavior of these systems (avalanche cycles) is predictable, but the behavior of individual events ("Will this slope slide today?") is not. There is an irreducible element of chaos in the system. No matter how good our data is, it will never be entirely predictable. Thus, stability evaluation is helpful but we cannot rely on stability evaluation to keep us out of trouble.

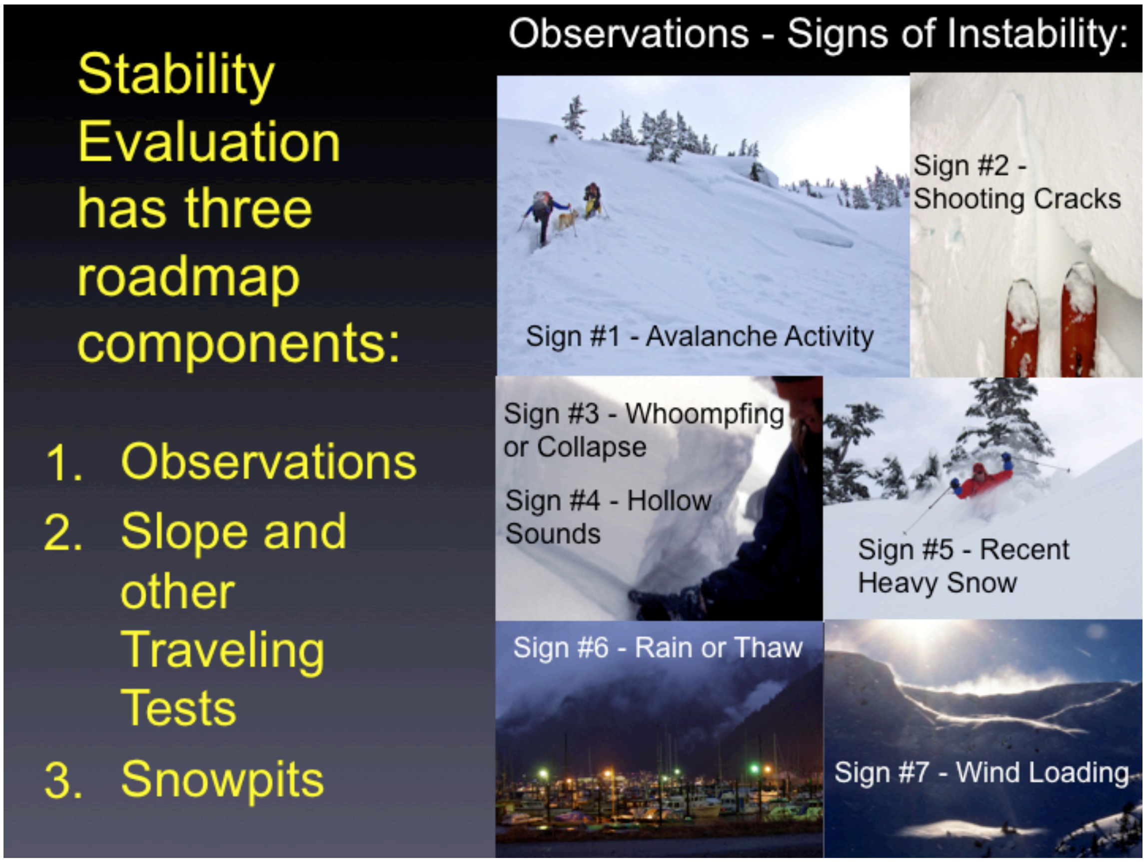
Standards for Tests and Observations

- We teach and follow the US field observations guidelines in *Snow, Weather, and Avalanches: Observational Guidelines for Avalanche Programs in the United States (*SWAG), jointly published by the American Avalanche Association (AAA) and the USDA Forest Service National Avalanche Center (NAC), available online or to order in printed format in the Publications section of the AAA website , http://www.americanavalancheassociation.org/
- We use the SWAG guidelines as a text for Level 2 and higher courses, but we also encourage serious Level 1 students to study them. This paper is intended as a summary and supplement, pointing to the most useful tests and observations for fieldwork in Southeast Alaska, noting those most suitable for everyday field evaluation, adding some useful tests that have not yet made it into the guidelines, and adding material on stability evaluation and note-taking. Consult the SWAG guidelines, we refer to them daily in our work!
- The SWAG guidelines are intentionally flexible. They allow for a broad range of choices, and were specifically intended to not discourage innovation, to be a floor rather than a ceiling. Feel free to do better-than-minimum work and to innovate and improve! Test your innovations carefully, document their performance, and get them into the next edition.
- When in areas that adhere to the Canadian OGRS standards, we teach to their criteria, which differ slightly from those in the SWAG guidelines.

Learning to evaluate snow stability is a lifetime process. It can seem overwhelming, so we have made up this roadmap to help you find your way as you get started.

A Road Map for Stability Evaluation

Stability Evaluation Has Three Roadmap Components:



Stability 1, Observations

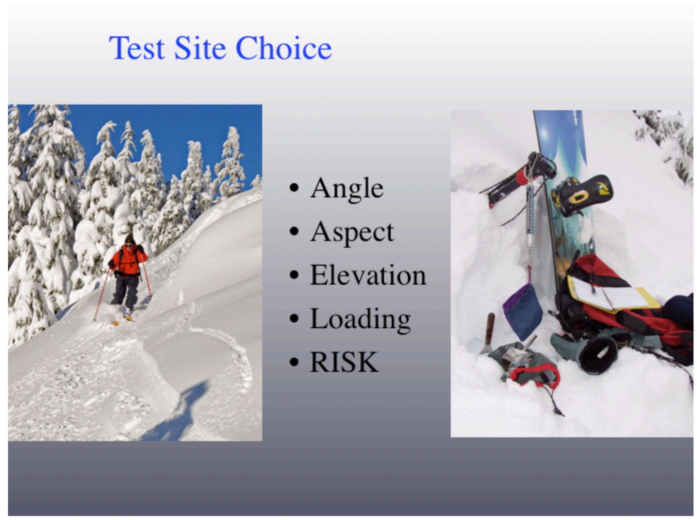
Observations - Key Signs of Instability
Observations are a major factor in your stability evaluation. Tally up how many of Doug Fesler and Jill Fredston's seven signs of instability you are observing, then weight their magnitude and significance. Remember that the absence of a sign can be as important as its presence.

1. **Avalanche activity** - Recent activity is the clearest indicator of instability!
2. **Shooting cracks** - Major indicator.
3. **Whoompfing or collapse** - Major indicator.
4. **Hollow sounds.**
5. **Recent heavy snow.**
6. **Rain or thaw.**
7. **Wind loading.**

Observation - Key Elements

- Observations - Weather
    - Past, history of the winter
    - Present
    - Trend

        - Forecast
    - Observations - General Awareness
        - Stay alert, stay present.
        - Keep your head on a swivel and your eyes moving.
        - Watch the ridges.
        - Watch for weather changes.
        - Watch for other parties, use them as “test dummies” but stay out from below them.
        - Use all your senses.
        - Hit the small test slopes, cornices, and drifts. Do quick tests as you travel.
        - Stop, look, and talk. Pool everyone’s observations.
        - Scout the best locations to stop for pits and snow tests.
        - Use resources outside your party, the web, the backcountry grapevine.



Stability 2, Slope and Traveling Tests - Site Choice

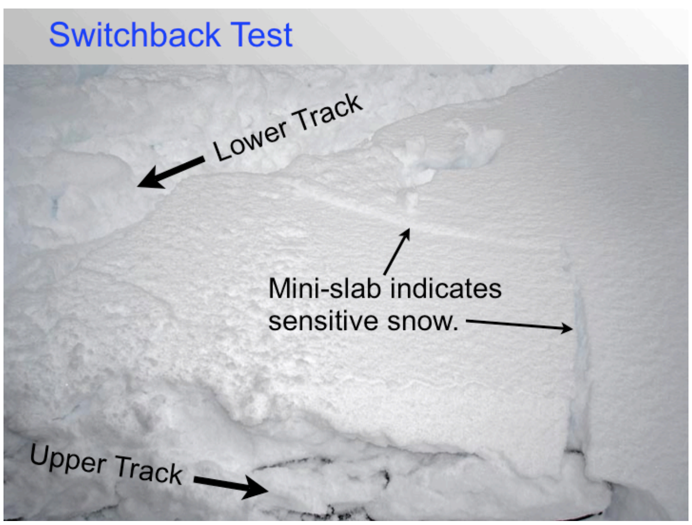
- **Angle** (38°-45° ideal)
- **Aspect** (Match to slope in question.)
- **Elevation** (Match to slope in question.)
- **Loading** (Match to slope in question, err toward more loading.)
- **RISK** (May require compromising other factors.)

Stability 2, Slope and Traveling Tests

Slope and traveling tests are those that can be done quickly as you travel, without taking your pack off or your shovel out. They are less precise than most snowpit tests, but are valuable because they allow rapid sampling over a wide area with very little time and effort. Those that involve digging are limited to soft new or windloaded layers that can be dug with the hands, but those layers are often the primary concern.

- **Slope Tests** - Ski, board, or bank cuts, jump tests, and trundling rocks or cornices. All are key tests, very useful. Be careful to test only small no-consequence slopes, but hit all you can as you travel.

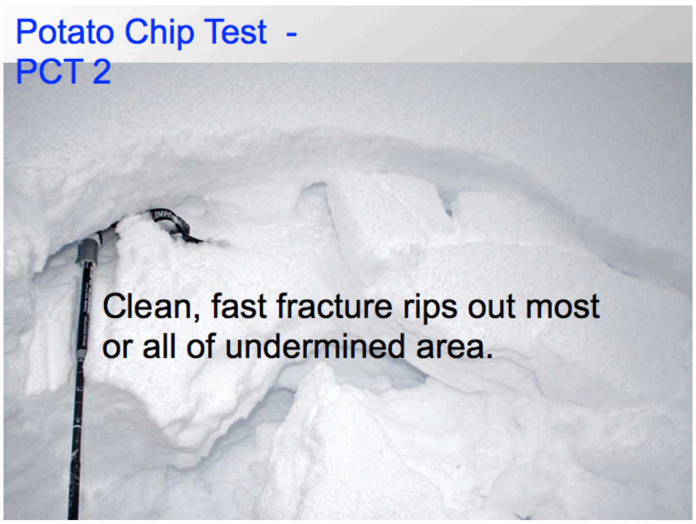
- **Drift and Cornice Tests** - Kick at small drifts and cornices to see if they crack or drop off. Note how they respond. Slow, irregular local cracking, or rapid, clean, large break? Easy or hard to trigger?
- **Switchback Test** - Try to cause fracture at the switchback by kicking at the wedge of snow it creates. Especially useful for new or windloaded snow. With fat skis or splitboards, back off your climbing angle near the turn so the wedge is not too broad.
- **Parallel Tracks Test** - Try to cause fracture by cutting one track above another. Also especially useful for new or windloaded snow. Bounce or kick to increase shear force as necessary.

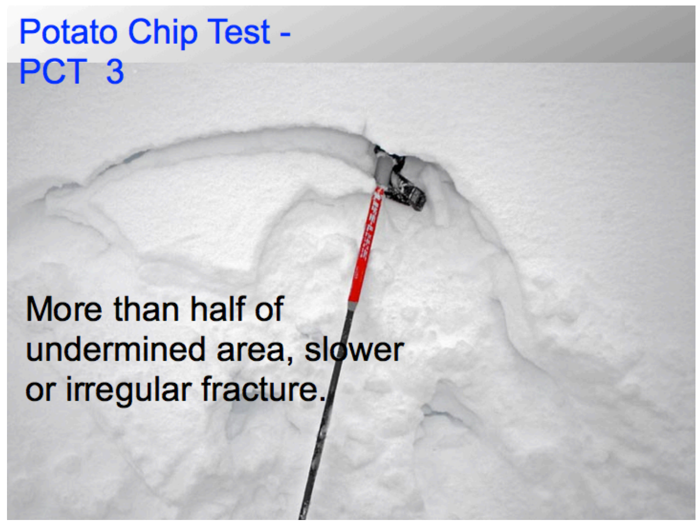


- **Probing** - Arm, ski pole, or probe. Use pole basket-first in soft snow; handle-first in harder snow. Allows rapid subsurface sampling over a large area. Works well for hard layers like rime crusts, frozen melt-freeze, or windslabs. Can detect depth hoar but does not work well on thin weak layers.
- **Potato Chip Test** (see notes and graphics) - A key test, index of how well the slab propagates fracture. Formerly called Slab Test.
- **Hand Shear, Ski Pole Block** (see graphic) - A key test, very quick, easy to do often without investing much time.
- **No Excuse Block** (see graphic) - A key test. The fastest large block test (“no excuse” to skip it!), particularly suited to snowboards on descent.


Probing With a Ski Pole
Basket first in soft snow.
Handle first in firmer snow.

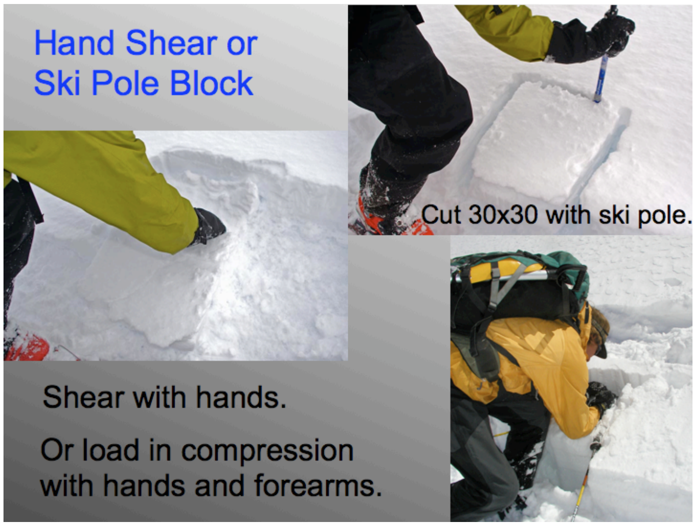

Potato Chip Test - PCT 1
Clean, fast fracture beyond undermined area.

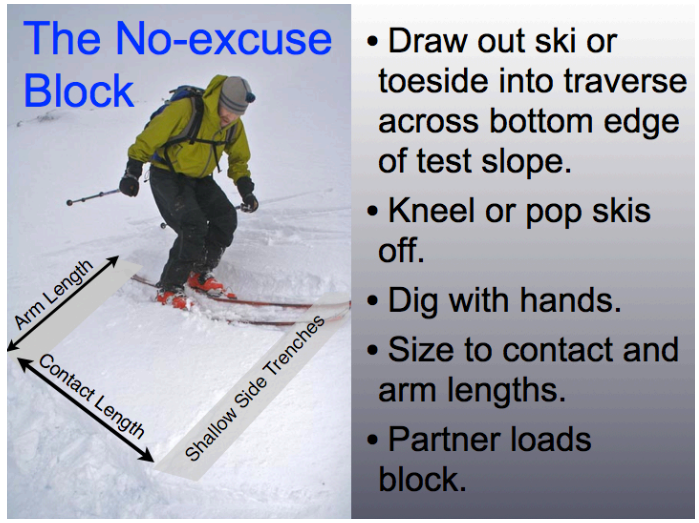

Potato Chip Test - PCT 2
Clean, fast fracture rips out most or all of undermined area.


Potato Chip Test - PCT 3
More than half of undermined area, slower or irregular fracture.


Potato Chip Test - PCT 4
Less than half of undermined area, slower irregular fracture.


Potato Chip Test - PCT 5
Irregular crumbling in and near loaded area.





Stability 2, Slope and Traveling Tests - Potato Chip Test Notes

Potato Chip Test (PCT)

Nonstandard traveling test. **Evaluates how well the slab propagates fracture, not how easily it breaks**, which varies with slab thickness, strength, and hardness. Dig weak layer out so slab is undermined to arm's or ski pole length, load slab by striking with both hands if it does not fracture on its own. **Observe how the slab fractures.** Does it rip out surrounding snow, all of undermined area, more than half, or less than half of the undermined area? Is it clean and fast, average, or just localized irregular crumbling? In other words, is the slab dead or alive? It's called the Potato Chip test because it tests whether the slab snaps like a fresh potato or corn chip right out of the bag, like the chips left out on the table overnight, or like the ones in your rucksack from the last trip.

The Potato Chip Test scale is:

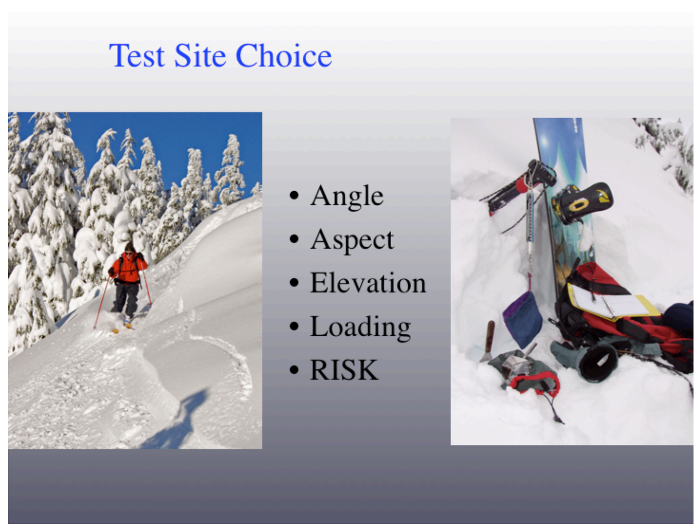
1 - Clean, fast fracture extends beyond undermined area.
2 - Clean, fast fracture rips out most or all of undermined area.
3 - More than half of undermined area, slower or irregular fracture.
4 - Less than half of undermined area, slower, irregular fracture.
5 - Irregular crumbling in and near loaded area.

Stability 3, Snowpits - The Quick Pit Chant

Remember, multiple quick pits are far more useful than one detailed pit.

1.) Pick a representative site.
- Angle (38°-45° ideal)
- Aspect (Match to slope in question.)
- Elevation (Match to slope in question.)
- Loading (Match to slope in question, err toward more loading.)
- **RISK** (May require compromising other factors.)

2.) Lay out block tests.

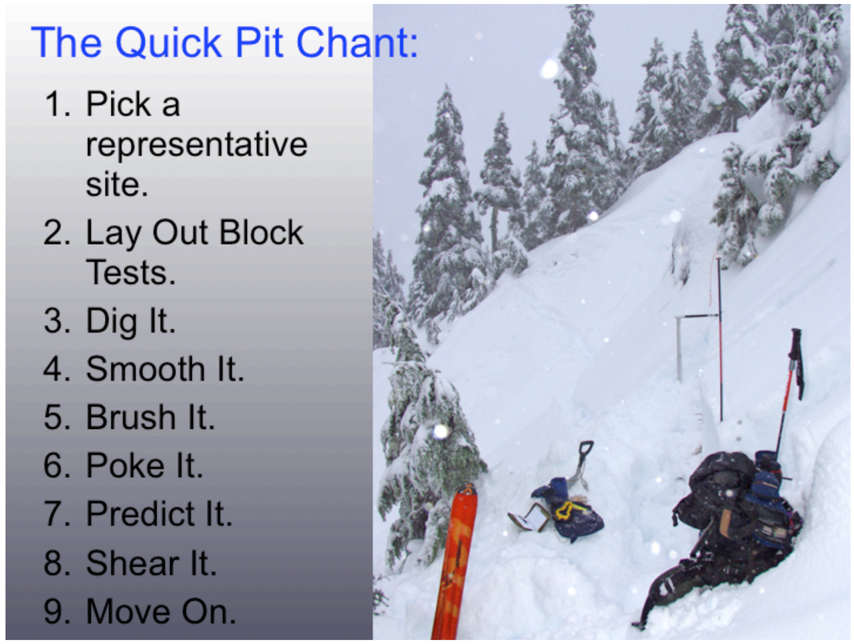


3.) Dig it.
- Mechanical strength.
- Density.
- Sound.

4.) Smooth it.
- Visual.
- Strength.
- Sound.

5.) Brush it.
- Visual.
- Hardness.
- Sound.

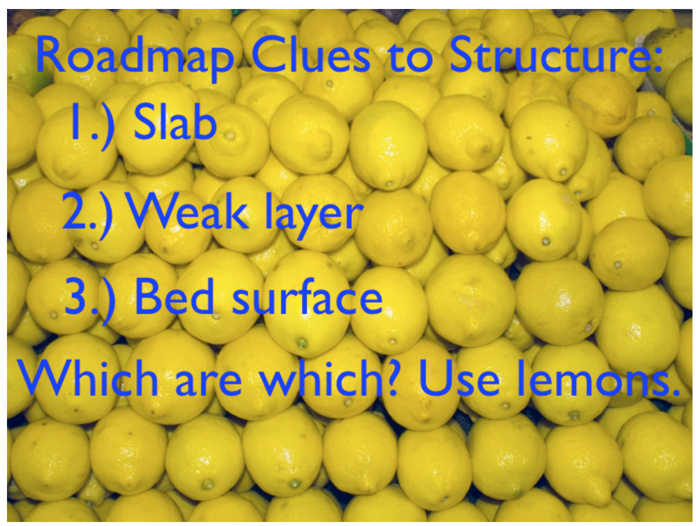
6.) Poke it.
- Use R Hardness Scale:
  F - fist
  4F - 4 finger
  1F - 1 finger
  P - pencil
  K - knife
  I - impenetrable



- Identify grain type E, use our short ICSI classification list first, avoid subclasses but add if necessary for description or technical study.
- Pick out Lemons (weak layer depth, thickness, grain type, hardness difference, grain size difference) and Yellow Flags (WEAK LAYER: grain size, hardness, persistence; INTER-FACE: grain size difference, hardness difference, depth).

7.) Predict it.
8.) Shear it.
9.) Move on.

Stability 3, Snowpits - Lemons
In ongoing studies 4 or 5 lemon factors have been shown to correspond to weak structure, regardless of block test values. Ian McCammon and Jürg Schweizer's lemons are a very useful tool to help pick out likely slab, weak layer or weak bond, and bed surface combinations. Key Stability Wheel input. Assign one lemon to an interface for each of these qualities:
- Weak layer depth ≤ 1m.
- Weak layer thickness ≤ 10 cm.
- Weak layer grains persistent grain type (facets or surface hoar).
- Hardness difference ≥ 1 step on the scale.
- Grain size difference ≥ 1 mm.



Stability 3, Snowpits - Yellow Flags
Jürg Schweizer and Bruce Jamieson came up with a slightly different checklist in a later study using a different data set and called their key factors Yellow Flags to distinguish them from the list of lemons. It is worth checking against both lists.
- Weak Layer Grain Size >1 mm.
- Weak Layer Hardness < 1Finger.

- Weak Layer Grains Persistent.
- Interface Grain Size Difference > 0.5 mm.
- Interface Hardness Difference >1 Step.
- Interface 20-85cm Deep.

Stability 3, Snowpits - Shear Quality

Quality 1 shears have a high correlation with unstable conditions, regardless of block test values. Ron Johnson and Karl Birkeland's shear quality is another key stability wheel input.

Q1 - clean and fast shear
Q2 - average shear
Q3 - irregular or incomplete shear

Stability 3, Snowpits - Fracture Character

An alternate way of noting fractures, developed by University of Calgary, best with small block tests.

SDN - Sudden Fractures (Typically Q1):
  SP - Sudden Planar, thin planar, crosses in one loading step and slides easily
  SC - Sudden Collapse, crosses in one loading step, noticeable collapse
RES - Resistant Fractures:
  PC - Progressive Compression, noticeable thickness, crosses on one loading step, compresses more on additional load (typically Q2 or 3)
  RP - Resistant Planar, planar or mostly, more than one loading step or does not slide easily (typically Q2)
  BRK - Break (typically Q3).

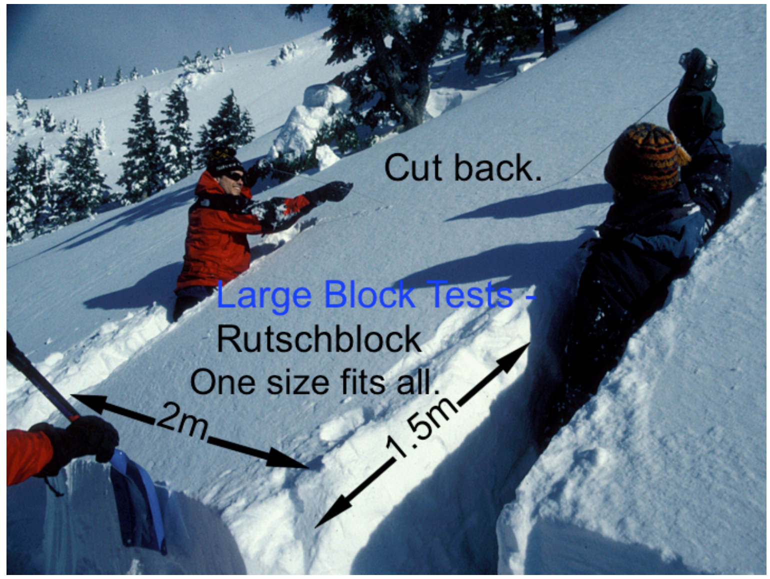
Stability 3, Snowpits - Optional Pit Observations

These are commonly used for technical snow studies, but are optional for non-specialists.

- "Credit Card test", crystal card sliced through pit wall on edge (very useful for finding thin crusts).
- Moisture Content θ_w
  - Dry, no one-handed snowball.
  - Moist, makes snowball.
  - Wet, makes wet snowball.
  - Very wet, makes your gloves wet.
  - Slush, saturated.
- Temperature Profile (use calibrated dial-stem thermometer, useful for detecting temperature gradients that cause faceted grains).
- Density ρ_S (use a density kit if available and desired).

Stability 3, Snowpits - Small Versus Large Block Tests

Large Block Tests



- Sample a large enough area to minimize the effect of small-scale spatial variability.
- Simulate human-triggering of slabs very well.
- Are simple; suitable for anyone with skis or snowboard to load block.
- Minimal gear needed - the AK Block can be done with only a shovel and skis or board marked with your block size. The jump test can be done with only a shovel, so it works for all snow travelers.
- Are relatively error-tolerant.
- Same time as standard small block test set.
- More time digging; less time on preparation and testing.
- Good for cold days because more digging helps to stay warm, and test requires only a shovel and marked gear so less gear needs to be pulled out and set up.
- Give gut-level feedback for the strongest decision-making input as the block slides out from under the tester.
- Do not test soft surface layers well. Skis and snowboards tend to sink immediately through soft surface layers without shearing them.
- Requires at least 30° slope angle for reliable results; 38°-42° best.
- The Rutschblock requires skis or board and a specialized snow saw or very deep digging and soft snow to saw far enough with a cord to make a clean, deep back cut. Snowshoes work sometimes, but only if snow conditions are suitable. The AK Block is not effective with snowshoes.

Small Block Tests

- Work well for testing soft surface layers.
- Can be done without skis, snowshoes, or snowboard; work well for all snow travelers.
- Can yield good results on gentler slope angles.
- Same time for standard small block test set as for AK Block.
- More time setting up and testing, less time digging.
- Require precise cutting to achieve consistent results.
- Sample only a tiny area, allowing spatial variability to easily skew the results. Repetition necessary for reliable results.
- Give only intellectual-level feedback as the fracture is observed.
- Require a snow saw, awkward to saw with a cord.

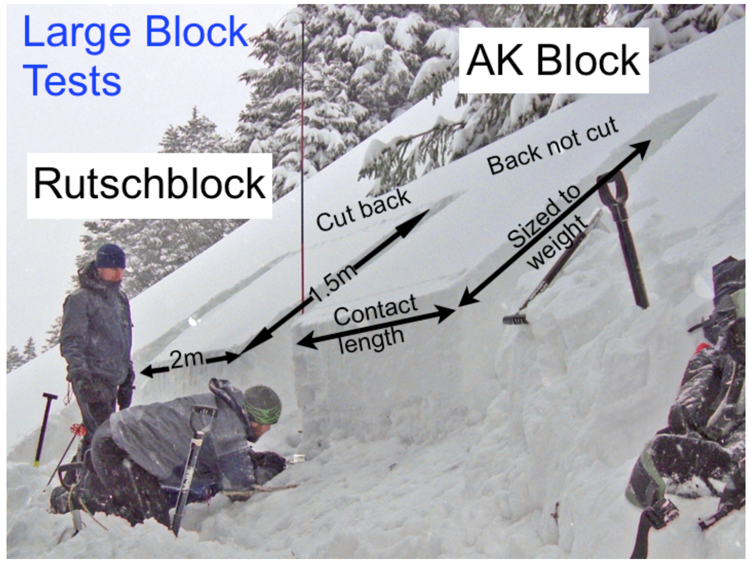
Stability 3, Snowpits - The Most Useful Large Block Tests

Rutschblock (RB, note slope angle, depth, and tester weight. Requires skis, snowboard, or splitboard; can use snowshoes in some conditions).

Standard large block test, pure shear test. Dig 2 m long trench across slope to slab depth or about 2 m maximum, cut or trench sides for 1.5m height (slope distance on fall line). One size fits all testers. Cut back with specialized long saw. Ski pole mounted saw works if layers are all soft. Beware cutting back with cord, usually results in incomplete arched cut. Rider loads block.

AK Block (AK, note slope angle and depth. Requires skis, snowboard, or splitboard.)

Still a nonstandard test, but proving reliable in practice and statistical analysis. Large block test, measures shear strength, slab properties, and propagation. Dug and loaded similarly to Rutschblock, but sized to ski or board contact length and tester weight, and back is NOT cut. Faster to set up. Sides can be cut but must also be trenched enough so board ends do not hang up. Ongoing testing by Alaska Avalanche Specialists. Details are on the AAS website, www.akavalanches.com/.



No-excuse Block (NE, note slope angle and depth. Requires skis, snowboard, or splitboard)

A nonstandard large block traveling test. Very fast, good for fairly shallow soft snow over a known base. On snowboards, the first rider cuts low toeside on a test slope, kneels and digs block with hands. Size block to board contact length and arm length. Second rider waits above to shear the block. Works for skiers too, a little slower because skis must be removed for digging.

Jump Test (JUMP. Works for all snow travelers.)

Nonstandard test cut as for Rutschblock, but sized to number of people, 1.25m wide for one, add one shoulder width per additional person. All stand upslope and link arms, flex knees first, then jump onto block. Repeat as necessary. Hard to quantify but works for all travelers. Can be varied by not cutting back, sides, or even front to test weaker snowpacks.

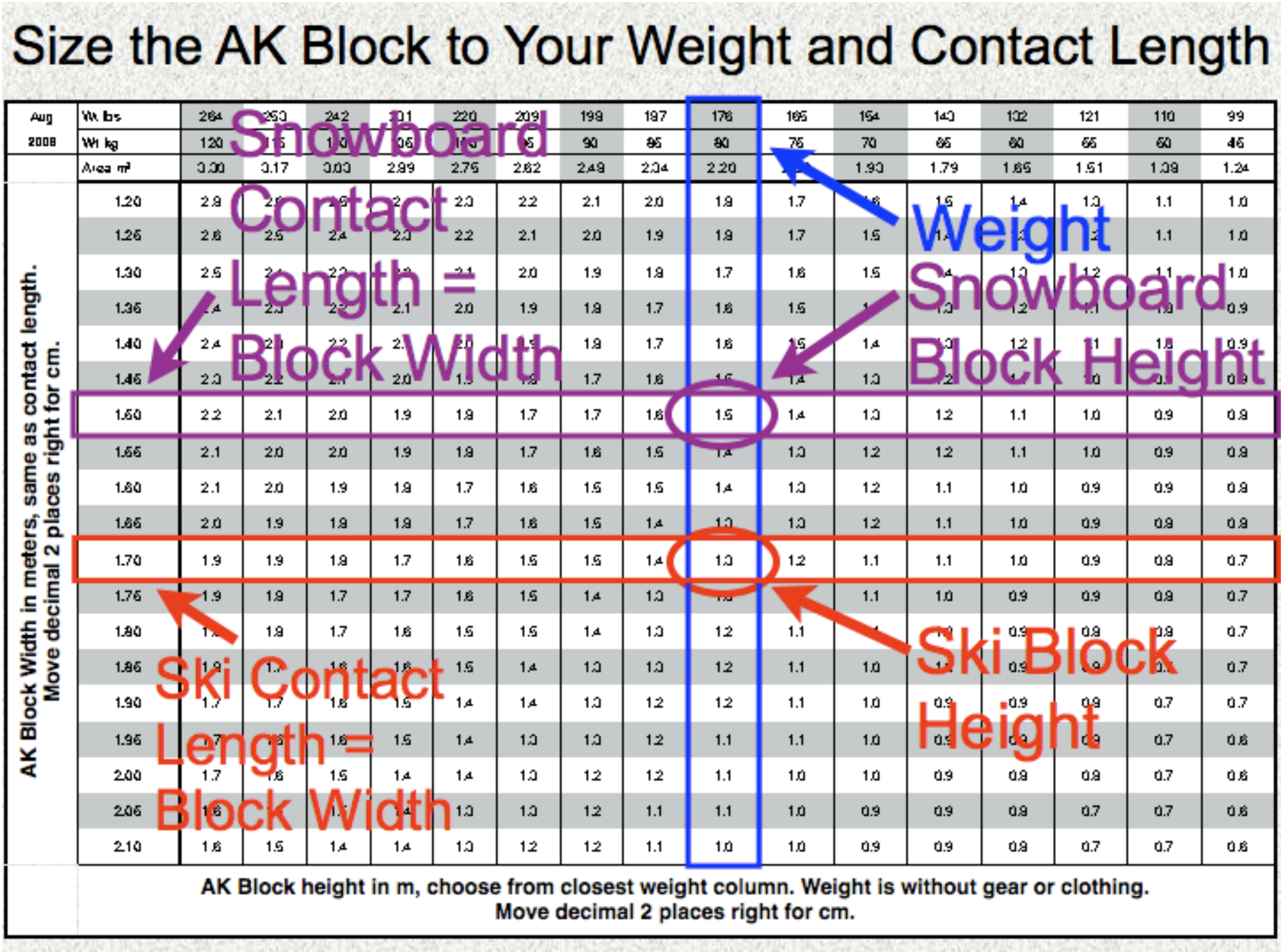
Stability 3, Snowpits - AK and No Excuse Block Loading Scale (AK, NE, note angle, shear quality, % released, depth)

1 Fractures during setup.
2 On approach, first gentle load, or shear push.
3 On knee flex.
4 On first, moderate jump.
5 On second, hard jump.
6 AK On three vertical jumps at top, RB step down to mid-block.
6.5 AK Three hard “shear kick” jumps.
7 No fracture.

NOTE: Refer to SWAG for the official Rutschblock (RB) loading steps and recording; be sure to record RB tester weight.

Stability 3, Snowpits - AK Block Sizing Table

Take your weight without clothing, measure the contact length of whatever you are riding as your block width. The table gives block height (up and down slope) where contact length and weight intercept. An example is highlighted on the graphic. This is the current working version. Ongoing research is fine-tuning the table. We recommend sizing test blocks as an improvement over not sizing them, but be cautious about assuming that results will be directly comparable between testers of different weights until the final phase of research is completed and published. Refer to the most recent AK Block papers in the Research section of the Alaska Avalanche Specialists website at www.akavalanches.com/ for the most-current sizing table.



Avg 2008	Wt lbs	264	253	242	[illegible]	220	209	198	187	176	165	154	143	132	121	110	99
	Wt kg	120	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	90	85	80	75	70	65	60	55	50	45
	Area m²	3.30	3.17	3.03	2.89	2.75	2.62	2.48	2.34	2.20	[illegible]	1.93	1.79	1.65	1.51	1.38	1.24
AK Block Width in meters, same as contact length. Move decimal 2 places right for cm.	1.20	2.9	[illegible]	[illegible]	[illegible]	2.3	2.2	2.1	2.0	1.9	1.7	[illegible]	1.5	1.4	1.3	1.1	1.0
	1.25	2.8	2.5	2.4	2.3	2.2	2.1	2.0	1.9	1.9	1.7	1.5	[illegible]	[illegible]	[illegible]	1.1	1.0
	1.30	2.5	[illegible]	[illegible]	[illegible]	[illegible]	2.0	1.9	1.8	1.7	1.6	1.5	[illegible]	[illegible]	[illegible]	1.1	1.0
	1.35	[illegible]	[illegible]	[illegible]	2.1	2.0	1.9	1.8	1.7	1.6	1.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.9
	1.40	2.4	[illegible]	2.2	[illegible]	[illegible]	[illegible]	1.8	1.7	1.6	1.5	1.4	[illegible]	1.2	[illegible]	[illegible]	0.9
	1.45	2.3	[illegible]	[illegible]	2.0	[illegible]	[illegible]	1.7	1.6	[illegible]	[illegible]	1.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	1.50	2.2	2.1	2.0	1.9	1.8	1.7	1.7	1.6	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.8
	1.55	2.1	2.0	2.0	1.9	1.8	1.7	1.6	1.5	[illegible]	1.3	1.2	1.2	1.1	1.0	0.9	0.8
	1.60	2.1	2.0	1.9	1.8	1.7	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.0	0.9	0.9	0.8
	1.65	2.0	1.9	1.8	1.8	1.7	1.6	1.5	1.4	[illegible]	1.3	1.2	1.1	1.0	0.9	0.8	0.8
	1.70	1.9	1.9	1.8	1.7	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.1	1.0	0.9	0.8	0.7
	1.75	1.9	1.8	1.7	1.7	1.6	1.5	1.4	1.3	[illegible]	[illegible]	1.1	1.0	0.9	0.9	0.8	0.7
	1.80	[illegible]	1.8	1.7	1.6	1.5	1.5	1.4	1.3	1.2	1.1	[illegible]	[illegible]	0.9	0.8	0.8	0.7
	1.85	[illegible]	[illegible]	[illegible]	[illegible]	1.5	1.4	1.3	1.3	1.2	1.1	1.0	[illegible]	0.9	[illegible]	[illegible]	0.7
	1.90	1.7	1.7	1.6	1.5	1.4	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.9	0.9	0.7	0.7
	1.95	[illegible]	[illegible]	1.6	1.5	1.4	1.3	1.3	1.2	1.1	1.1	1.0	[illegible]	[illegible]	[illegible]	0.7	0.6
	2.00	1.7	[illegible]	1.5	1.4	1.4	1.3	1.2	1.2	1.1	1.0	1.0	0.9	0.8	0.8	0.7	0.6
	2.05	[illegible]	[illegible]	[illegible]	[illegible]	1.3	1.3	1.2	1.1	1.1	1.0	0.9	0.9	0.8	0.7	0.7	0.6
	2.10	1.6	1.5	1.4	1.4	1.3	1.2	1.2	1.1	1.0	1.0	0.9	0.9	0.8	0.7	0.7	0.6

AK Block height in m, choose from closest weight column. Weight is without gear or clothing. Move decimal 2 places right for cm.

Stability 3, Snowpits - The Most Useful Small Block Tests

Tap Compression Test, or Compression Test (CT, note angle and depth, works for all snow travelers).

The best small block test in terms of accuracy, speed, and quantifiability. Must be cut carefully for consistent results. Cut 30 x 30 cm column, cut sides and back. Place shovel blade on top, tap on blade. Increase force by hinging from farther up arm. Fast-est quantifiable small block test. Watch carefully, often does not slide on fracture. The scale is

- VERY EASY fractures when cut, CTV. EASY taps from wrist, CTE 1 to10.
- MODERATE taps from elbow, CTM 11 to 20.
- HARD taps from shoulder, CTH 21 to 30; or no fracture, CTN.

Deep Tap Test (DT)

Test for layers deeper than Compression Test is effective on.First Identify layer to be tested. Trim column 15 cm above back of suspect layer. Load as for Compression Test. Note shear quality and character.

Stuffblock Test (SB, 4.5 kg snow weight, note angle and depth).

Standard small block test, same as tap compression test but loaded by dropping a stuffsack with 4.5 kg (10 lbs) of snow onto the shovel. Best-quantified small block test but takes a little more time and equipment than tap compression test. Must be cut carefully for consistent results. The scale is

- SBV fractures during isolation/cutting.
- SB0 fractures on static load (no drop).
- EASY, drop snow bag onto shovel, +10 cm, SB10 to 20.
- MODERATE, SB 30 to 40.
- HARD, SB 50 to 70, or no fracture SBN.

Shovel Shear Test (ST)

Considered a standard test but not recommended for evaluating shear strength. Does not pick out the most significant layers, unquantifiable, not very useful except on the flats or to get an undisturbed sample of a weak layer. Cut 30 x 30 cm column on sides and back, slip shovel bit by bit down back, pull it toward you to shear, slice off top of column to continue when curve near end of blade is reached. Must be cut carefully.

Stability 3, Snowpits - The Potato Chip Test (PCT)

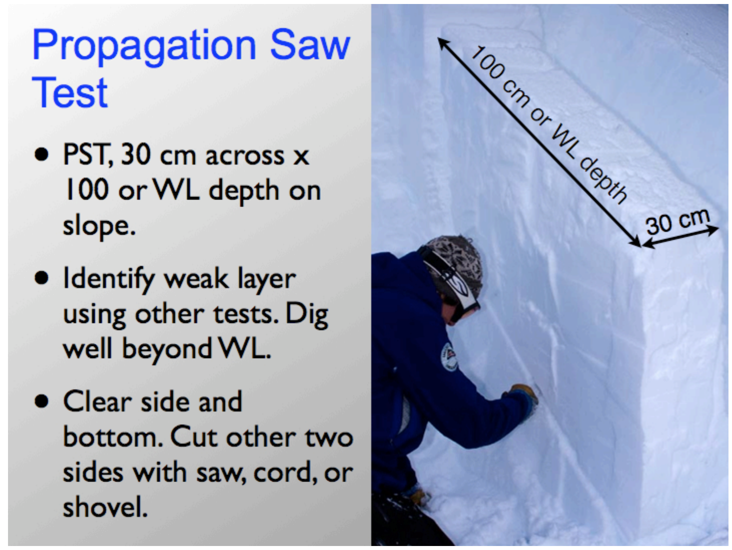
The Potato Chip Test is described above under Stability 2 Slope and Traveling Tests, but it is often useful to do a Potato Chip Test right next to the block tests as part of your snowpit studies.

Stability 3, Snowpits - Propagation Tests

Extended Column Test, new standard test in 2009.

- **ECT**, 90 cm across x 30 on slope.
- Load at one end with taps on shovel as for compression test.
- # = number of taps on which fracture initiates
- ECTP # - Propagates to end (on one or two taps, # or #th +1 taps).
- ECTN # - Little or no propagation.
- ECTX - No initiation or propagation.
- Also note layer, angle.
- Propagation likely if fracture to end on any tap or that tap plus 1.
- Example: ECTP 8 on ◩ ↓ 51 cm 42°.

Propagation Saw Test, new standard test in 2009.



- Identify weak layer using other tests. Dig well beyond WL.
- Clear side and bottom. Cut other two sides with saw, cord and probe, or shovel.
- Blunt edge of saw follows weak layer up-slope.
- Note as: PST x/y (arr, sf, end) on YYMMDD date of weak layer if known.
- x = cut length where fracture initiates.
- y = block length (100 cm or WL depth if WL depth >100 cm).
- Arr = fracture arrested before end of column.
- SF = slab fracture, fracture broke out as slab before end of block.
- End = fracture propagated to end of block.
- Note x/y (Arr, SF, End), layer depth, date; grain type, angle.
- Propagation likely if <50% of block is cut when fracture propagates to end.
- Example: PST 35/100 (End) ↓ 43 cm on 090203◩ 40°.

Stability 3, Snowpits - Choosing Your Tools and Testing Efficiently

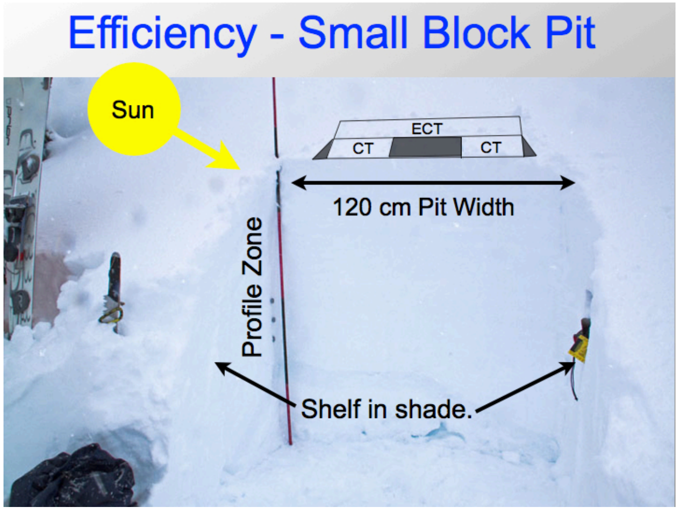
For efficiency, master these two standard pit layouts. Lay out the areas to be dug before you start digging. Move only the snow you need to move!

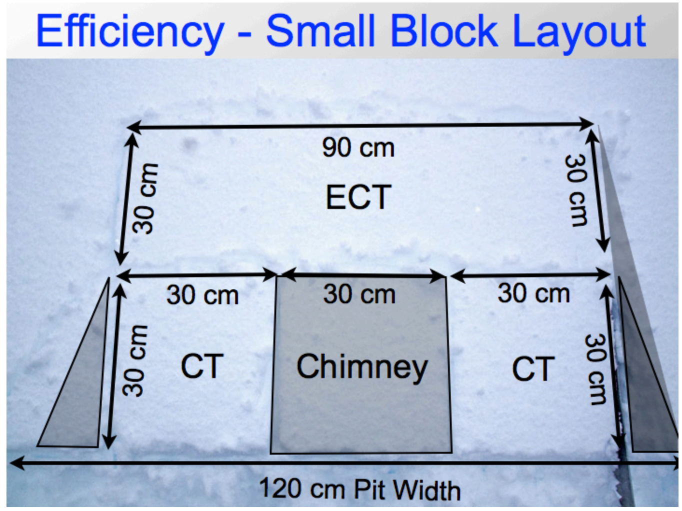
In our University courses, we find that both standard pits require the same amount of time, so choose the test set that is most appropriate to your situation:

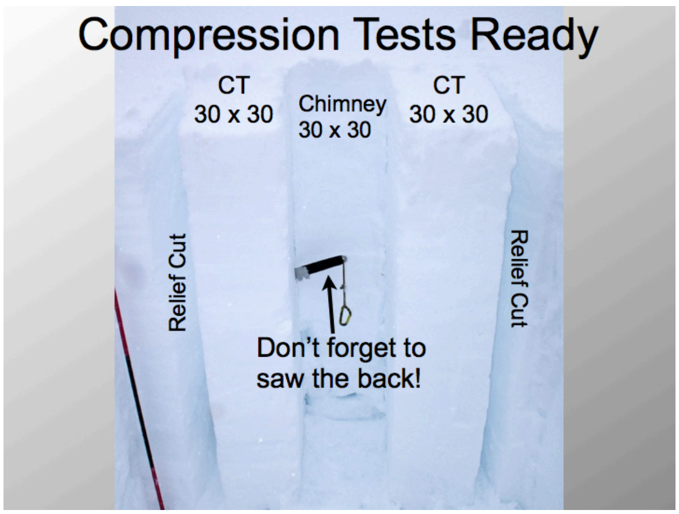
- Small block set - takes less time to dig, but more time to get out tools, cut with care, load, and note.
- Large block set - takes more time to dig but less time to lay out with marked gear, dig with a shovel, and load.
- Large block tools - all you need is marked gear and a shovel.

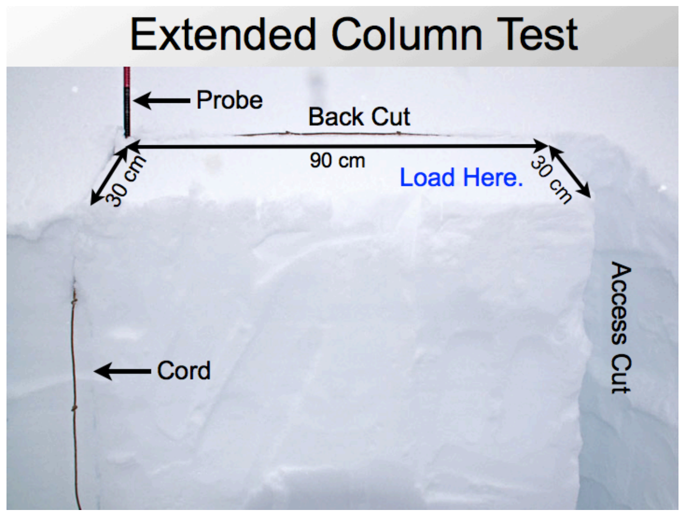
- Small block tools - you need a marked saw, a shovel, a probe, and cutting cord.
- If you must test on a low slope angle because steeper slopes are not available or are potentially dangerous - use small blocks.
- In very light snow, use small blocks. You are less likely to fall through near-surface layers when loading, especially on gentle slopes.
- If you have no skis or snowboards - use small blocks.
- For cold days, use large blocks. You stay more active and need minimal tools.
- If there is high spatial variability, use large blocks. Their larger size helps minimize effects.
- To find the most-significant weakness, use large blocks. Their closer simulation of human-triggering tends to more-clearly identify the layers that matter to us.
- To test propagation, either use propagation tests (the Extended Column Test or Propagation Saw Test), or use large blocks and record the percentage released.

1. Small Block Pit - Profile and set of two CT’s and one ECT

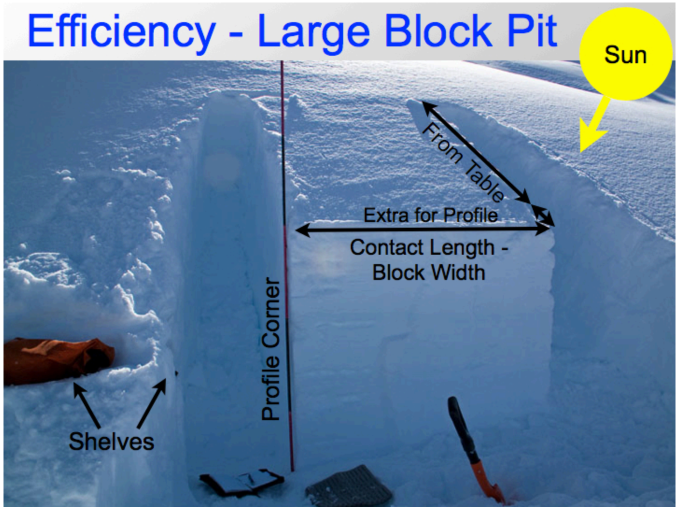


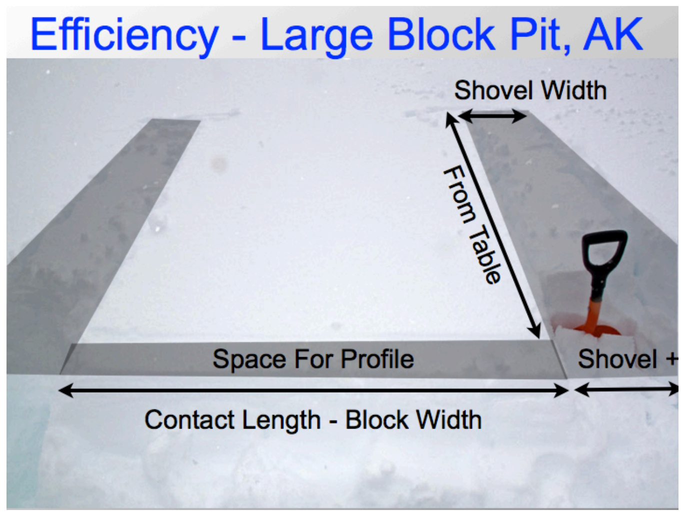


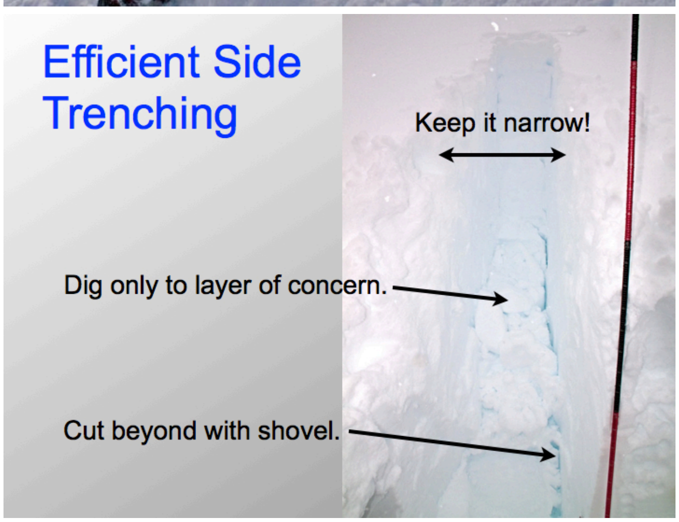


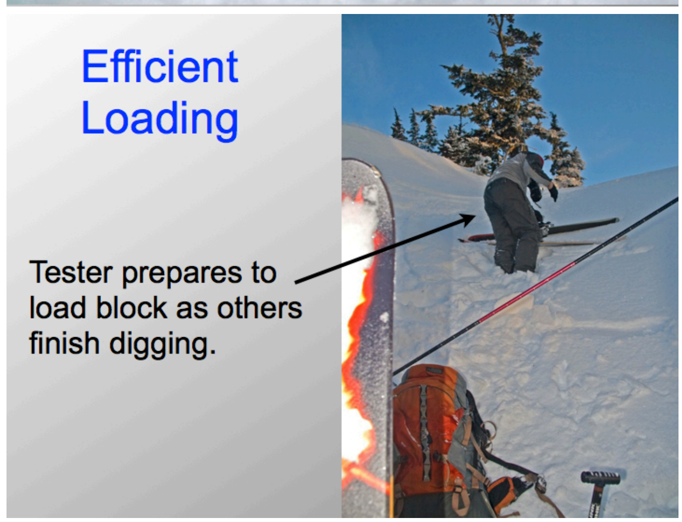


2. Large Block Pit - Profile and one AK Block









Stability 3, Snowpits - Other Sometimes-useful Tests

Collapse Test

Nonstandard test most useful with slab over depth hoar. Vertically load 30 x 30 cm block cut carefully on on all sides, observe for compressive collapse, **not** shear.

Tilt Test

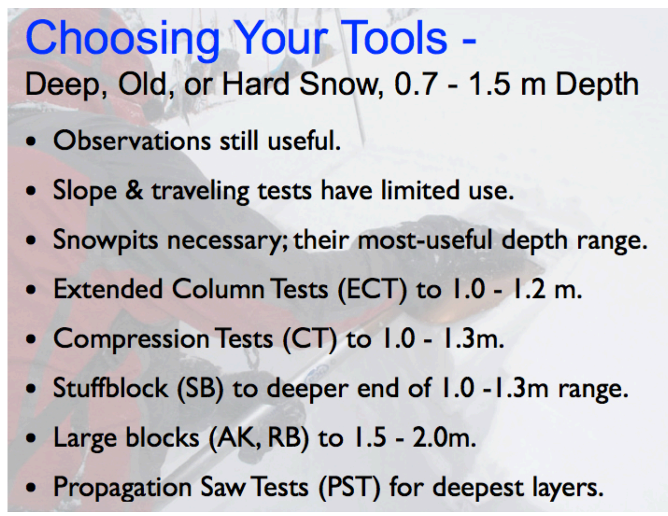
A nonstandard test most useful for identification of weak layers rather than evaluation of strength. Cut a shovel-size block of new snow, pick up with shovel blade, increase angle 10-15° beyond slope angle and tap shovel with increasing force to fracture, increase angle if needed. Record as easy, moderate, or hard. For weak layers in new snow only.

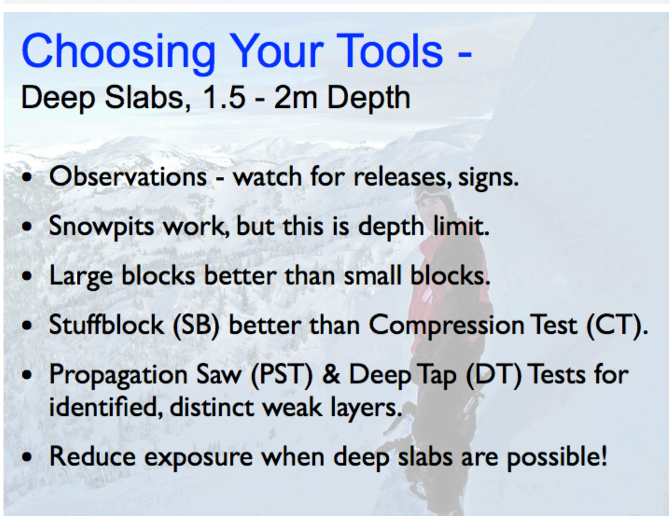
Loaded Column

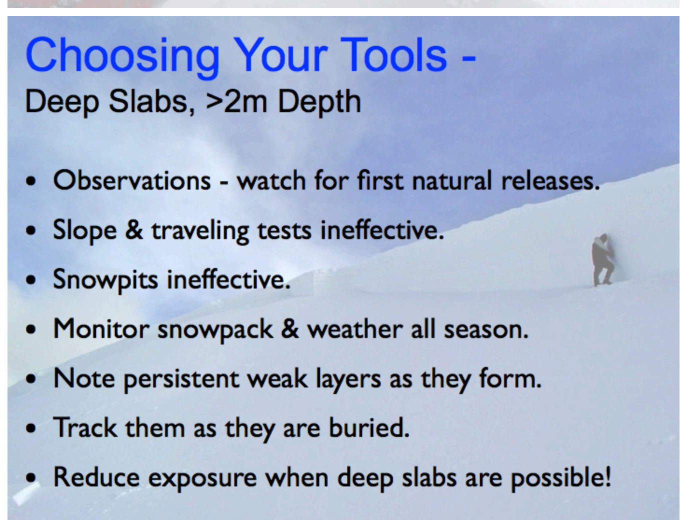
A nonstandard test. Load can be calculated but beware, less snow load (often half as much as test suggests!) has been observed to cause fracture in actual avalanche cycles. Cut a 30 x 30 cm column, cut sides and back, stack column-size snow blocks on it until fracture. Record shear plane, shear quality, and load (based on block density and size for load to fracture). Cut carefully for consistent results.

Choosing Your Tools - When to Use Observations, Slope and Traveling Tests, and Snowpits

All our tools have strengths and limitations. Here's a breakdown outlining what tools work best for different weak layer or slab depths and snowpack characteristics.



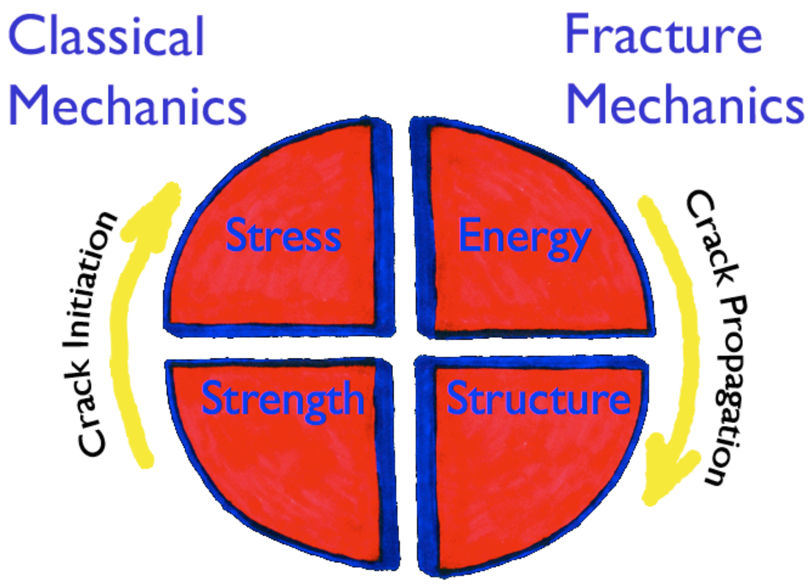




The Old Roadmap - Classical Mechanics Recipe for a Slab Avalanche (layers + gravity)

1. **slab**
2. **weak layer** (or poor bonding)
3. **bed** (or thick weak layer, distinct bed optional, but useful)
4. **stress-strength balance**
5. **stored elastic energy**

According to the simple model of classical mechanics, the stress-strength balance tips into fracture and release when the stress equals or exceeds the strength. The greatest chance of human-triggered slides comes as the stress approaches the strength, when it is easiest to tip the balance.

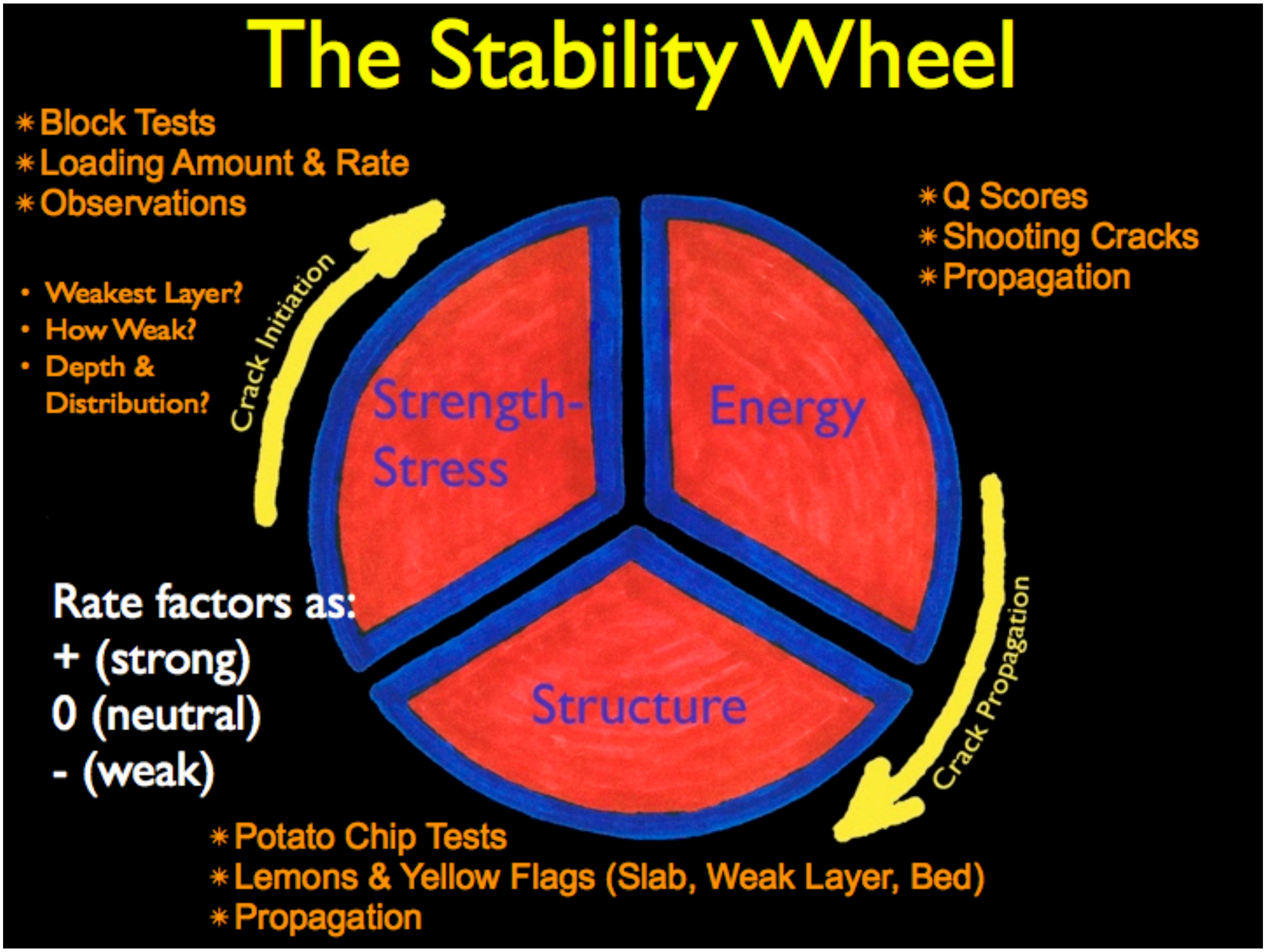


The New Road Map - Fracture Mechanics and the Stability Wheel

Classical Mechanics only deals with the factors that govern crack initiation. Fracture mechanics is a more complex and more accurate framework that includes the factors that govern crack propagation. We do not go into it until our Level 2 course, but for our purposes it gives us these four key components of the Stability Wheel:

1. **Strength indicators:** weakest layer, how much force to fracture, depth, and distribution, using block tests and observations.
2. **Stress indicators:** observed loading amount and rate.
3. **Energy indicators:** shear quality (Q scores), shooting cracks, propagation in tests.
4. **Structure indicators:** Potato Chip tests and slab, weak layer, and bed surface combination as evaluated using lemons or yellow flags.

The tests and observations we use give us a way to rate each of these fracture mechanics components, as listed in the stability wheel diagram. Since the tests we use for evaluating the snowpack include the stress of the snow load as well as its strength, we combine the stress and strength factors into one "strength versus stress" lobe. As a road map for interpreting our observations and tests, we rate each of the Stability Wheel factors as + (strong), 0 (neutral), or - (weak).


The Stability Wheel
* Block Tests
* Loading Amount & Rate
* Observations
• Weakest Layer?
• How Weak?
• Depth & Distribution?
Crack Initiation
* Q Scores
* Shooting Cracks
* Propagation
Strength-Stress
Energy
Structure
Crack Propagation
Rate factors as:
+ (strong)
0 (neutral)
- (weak)
* Potato Chip Tests
* Lemons & Yellow Flags (Slab, Weak Layer, Bed)
* Propagation

Summary - The Roadmap in Practice

1. **Observations**
   - Tally up how many of the seven signs you are observing, weight their magnitude and significance.
2. **Slope and Traveling Tests**
   - Evaluate test sites by angle, aspect, elevation, loading, and risk.
   - Use slope and traveling tests to sample quickly over a large area.
3. **Snowpits**
   - Choose test sites by angle, aspect, elevation, loading, and risk.
   - Use the Quick Pit Chant to guide you through the key steps
     - 1.) Pick a representative site.
     - 2.) Lay out block tests.
     - 3.) Dig it.
     - 4.) Smooth it.
     - 5.) Brush it.
     - 6.) Poke it.
     - 7.) Predict it.
     - 8.) Shear it.
     - 9.) Move on.
   - Check lemons and yellow flags, do your block and Potato Chip tests, note shear quality.
   - Plug your observations, slope and traveling tests, and snowpits into the Stability Wheel.

Evaluation

Summarize your results in terms of observations, slope and traveling test results, and the stability wheel factors of strength versus stress, energy, and structure on the +. 0, - scale. This process will give not give you a go/no go decision but it will give you a good index of the likelihood of triggering slabs.

Examples:

- Only three of seven key signs but all severe and significant: several medium size slabs, numerous shooting cracks, heavy SE wind loading. Slope Tests produce mini-slabs, Switchback and Parallel Tracks Tests produce same, Hand Shears weak, Potato Chip Test 2. No Excuse Block 3 at Q1 on 38°. Two lemon and two flag weak layer. Based on observations, slope and traveling tests, and snowpits, we rate strength versus stress - (strength and stress both -), energy - , and structure - .

- Three out of seven key signs, all minor: localized cracking in drifts, slight whoompf heard once, light NE wind loading. No results on slope tests. Hand shears weak. Potato Chip Test 4. No Excuse Block 3 at Q2 on 40°. AK Block 4 at Q2 on 35°. Four lemon and five flag weak layer. Based on observations, slope and traveling tests, and snowpits, we rate strength versus stress + , (strength - but stress strongly +) , energy + , and structure - .

Decision-making

Congratulations, you now have a good first-cut stability evaluation! Your next task is to factor that in with the likely size and consequences of potential slides, the timing, terrain, route-finding alternatives, and other decision-making factors specific to your situation, then decide what you are going to do. .

Decision-making/Observation Frameworks - The U.S. Backcountry Avalanche Danger Scale

We do not encourage people to offer avalanche danger levels to others unless they have the years of experience as avalanche forecasters and the daily field presence throughout the target area that it takes to do a proper forecast. Leave that job to professional forecasting programs, and beware of some online volunteer-based “forecasts” that do not have a daily field presence of well-trained, reliable professional observers.

It is helpful to know how the scale works so you can make good use of it when you are in an area where an advisory with a danger level is available. It is good to hone your skills by making your own personal estimate, and if you want to use rule-based decision-making support tools that require a danger level and you are in an area with no advisory, you will have to make at least an estimate.

It is a five-point scale, but it is really more useful to think of it as a four-point scale with an extra point added (“Extreme”) for the occasional days with activity so big that it is really off the everyday scale. The key thing is that you see the “Considerable” or, as we prefer to call it, “Serious” level not as the middle or as a non-threatening average, but as being on the high side, which is what it is intended to be.

North American Public Avalanche Danger Scale

Avalanche danger is determined by the likelihood, size and distribution of avalanches.

Danger Level		Travel Advice	Likelihood of Avalanches	Avalanche Size and Distribution
5 Extreme	4 5	Avoid all avalanche terrain.	Natural and human-triggered avalanches certain.	Large to very large avalanches in many areas.
4 High	4 5	Very dangerous avalanche conditions. Travel in avalanche terrain not recommended.	Natural avalanches likely; human-triggered avalanches very likely.	Large avalanches in many areas; or very large avalanches in specific areas.
3 Considerable	3	Dangerous avalanche conditions. Careful snowpack evaluation, cautious route-finding and conservative decision-making essential.	Natural avalanches possible; human-triggered avalanches likely.	Small avalanches in many areas; or large avalanches in specific areas; or very large avalanches in isolated areas.
2 Moderate	2	Heightened avalanche conditions on specific terrain features. Evaluate snow and terrain carefully; identify features of concern.	Natural avalanches unlikely; human-triggered avalanches possible.	Small avalanches in specific areas; or large avalanches in isolated areas.
1 Low	1	Generally safe avalanche conditions. Watch for unstable snow on isolated terrain features.	Natural and human-triggered avalanches unlikely.	Small avalanches in isolated areas or extreme terrain.

Safe backcountry travel requires training and experience. You control your own risk by choosing where, when and how you travel.

Decision-making/Observation Frameworks - The Southeast Alaska Urban and Industrial Avalanche Danger Scale

The committee that came up with the backcountry scale pretty much ignored our need in Alaska for an urban danger scale, and left industrial operations to devise their own scales. To avoid a confusing proliferation of unrelated danger scales, we recommend this scale for urban and industrial use:

Alaska Urban/Industrial Avalanche Danger Scale

CAUTION: This danger scale applies only to urban and industrial areas covered by this forecast program. Do not use for backcountry, ski area, or highway travel.

Danger Level		Likelihood of Avalanches	Avalanche Size and Distribution	Travel Advice - Developed Areas
5 EXTREME		Natural and human-triggered avalanches certain.	Destructive avalanches likely to reach developed areas.	Eliminate exposure to avalanche zones. Monitor avalanche forecasts.
4 HIGH		Natural avalanches likely; human-triggered avalanches very likely.	Destructive avalanches likely to come near or reach developed areas.	Minimize exposure in avalanche zones. Monitor avalanche forecasts.
3 CONSIDERABLE		Natural avalanches possible; human-triggered avalanches likely.	Destructive avalanches may come near or reach developed areas.	Be increasingly cautious in or under steeper terrain and in avalanche zones. Monitor avalanche forecasts.
2 MODERATE		Natural avalanches unlikely; human-triggered avalanches possible.	Destructive avalanches possible but unlikely to come near developed areas.	Normal caution.
1 LOW		Natural and human-triggered avalanches unlikely.	Destructive avalanches unlikely to come near developed areas.	Normal caution.

Decision-making/Observation Frameworks - ALP TRUTH

Ian McCammon and others have developed this useful decision-making mnemonic, also called Obvious Clues, very similar to the seven signs of instability but also including terrain and forecast factors. It is another good decision-making tool, like the red - yellow - green light ratings for terrain, snowpack, and weather that you are probably familiar with from Fesler and Fredston's *Snow Sense*.

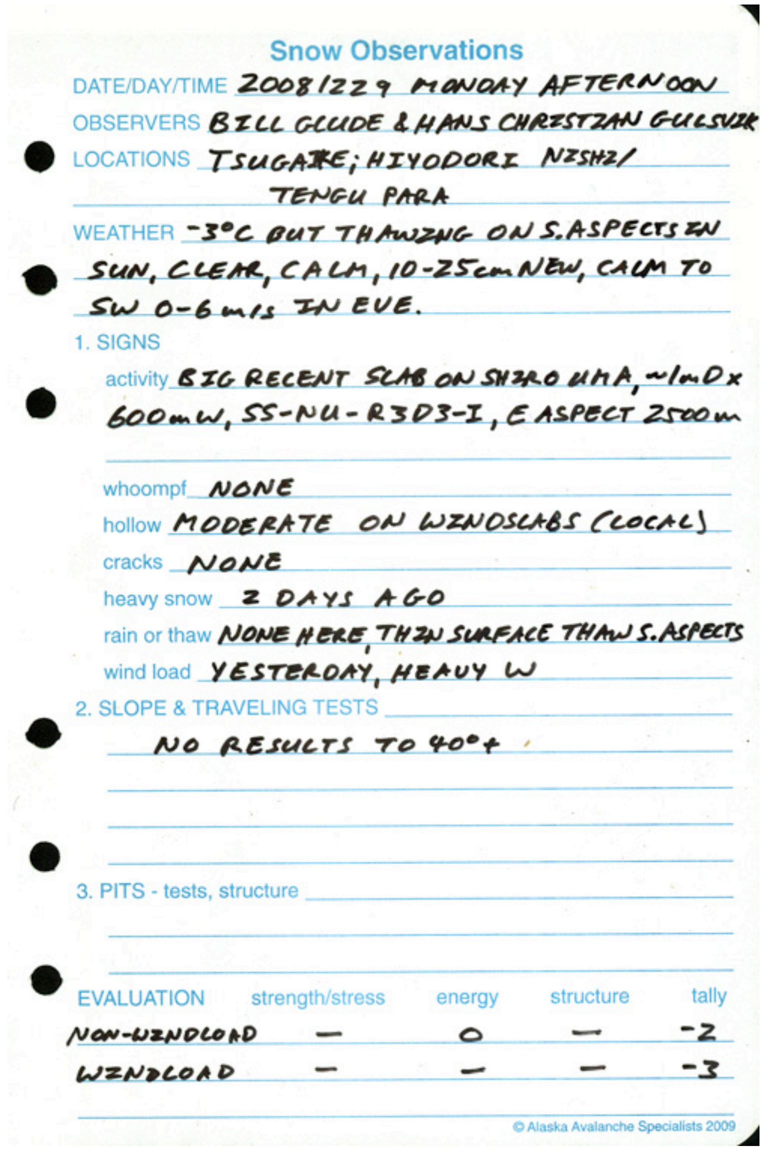
A - avalanches, in the area in the last 48 hours.
L - loading, by snow, wind, or rain in the last 48 hours.
P - path, identifiable by a novice.
T - terrain trap, gullies, trees, cliffs, or other features that increase the consequences.
R - rating, considerable or higher hazard on the current avalanche advisory.
U - unstable snow, collapsing, cracking, hollow snow, or other signs of instability.
TH - thaw, recent warming due to sun, rain, or warm air.

Keeping Avalanche Field Notes

- We have made up preprinted looseleaf weatherproof fieldbooks to serve as our standard format for recording field observations. Our fieldbook pages are updated frequently to follow the most-current SWAG (American Avalanche Association (AAA) observations standards), and are laid out in a clear, intuitive format that facilitates learning. The key pages function as a cheat sheet and checklist for decision-making and for filling out the forms. Most of the necessary information is summarized on them. The tips here are specific to our recording format, but can be adapted to others.
- The binders are larger, stiffer, and slipperier than would be ideal. We customize ours by adding the Cordura nylon zippered covers with pencil pockets, available directly online from JL Darling. We make them more flexible by cutting off the front and back plastic covers, leaving the plastic on the binder spine so the clip rings work, and then hand-sewing in velcro tabs to hold the spine in place.
- As of winter 2011-12, we are working on a lower-cost and more-compact spiral bound version of the fieldbooks. It will lack the ability to customize the page selection, but will be a bit cheaper and more compact for easy coat pocket use. We will choose a selection of pages geared more to quick assessment, rather than detailed professional analysis. That selection will include more aspect-elevation rose pages and a new single-page profile sheet, interspersed with level pages for other notes.
- The folks at the Gallatin National Forest Avalanche Center in Bozeman have developed the Snow Pilot system for recording field notes on a handheld device, and there are some other similar efforts. We had the same idea a few years ago and are excited at the prospect of taking notes with gloves on, and maybe eventually being able to post them directly on the web via our iPhones from the field. Snow Pilot is promising, but still does not have the graphical capability, flexibility, and customizability we need, and the original Palm Pilot technology has been bypassed by smartphones. In particular, it lacks a way to input AK Block or other newly-developed test data. It's getting really close, and we'd love to have the funding to modify the open source code for the features we need, but for now we're sticking with the fieldbook and pencil for to obtain the flexibility we need.
- The same applies to the computer programs available today. Snowpro is still a kludgey, inflexible, Windows-only program. The cross-platform Snow Pilot desktop version is a free download and is the best available but it still lacks the flexibility we need. We write our field notes by hand, ink them, and scan them. We will eagerly switch to electronic notekeeping once it is faster and better than what we can do by hand, but it is not here yet.
- If you want to set up your own fieldbook, start with an 11.75 x 17.78 cm (4 5/8 x 7") level fieldbook like the Rite in the Rain No. 311. Note all your general observations, then start the pit profile with a height scale on the left page. Use 10 cm per level book line. Set zero at the ground if it's reachable by digging or probing. Use a false zero if it's not. Set up the hardness scale - impenetrable (I), knife (K), pencil (P), 1 finger (1F), 4 finger (4F), and fist (F), as in our preprinted books. Half of the vertical column width on the level book works well for each hardness increment. Note temperatures to the left of the layer profile.
- Our preprinted AAS fieldbooks are geared to graphic representation. A graphic format reveals the critical patterns you need to make critical safety decisions in the field, makes it easier to catch mistakes while you are still there, and communicates your findings more clearly to others. But some people prefer tabular alphanumerical recording. If you want the best notebooks for tabular notation, we recommend Ian McCammon's (SnowPit Technologies) Snow and Avalanche Fieldbook or the Canadian Avalanche Association books.

Filling in the First Page - General Observations

- *Date* - Record using international format as 4 digit year-2 digit month-2 digit day.
- *Day* - Write out the day of the week.
- *Time of day* - The standard is to use 24 hour clock numbers for the time the observations began, but we find that morning, midday, afternoon, evening, or night is adequately descriptive.
- *Observers* - Who is taking these observations? List the principal observer first.
- *Locations* - Where are these observations from? Where have you been today? The location for observations purposes on the first page is the entire area you sampled, for the profile page, it is the specific location of the pit. You can use GPS or plotting to put latitude and longitude on it if you want to, but place names and a geographic description are adequate.
- *Weather* - These are the parameters recorded in the AAA standard observations. Some are not practical for backcountry fieldwork in our region, because they require a weather station and equipment that field observers will not have. The most important ones are the ones listed in the fieldbook key:
    - SKY (◯ CLR, ◔ FEW, ⦶ SCT, ◍ BKN, ⊕ OVC, ⊗ X, OBSCURED - means FOG)
    - PRECIPITATION TYPE, RATE, & AMOUNT
    - TEMPERATURE & SNOW LEVEL
    - WIND DIRECTION & SPEED
    - TREND

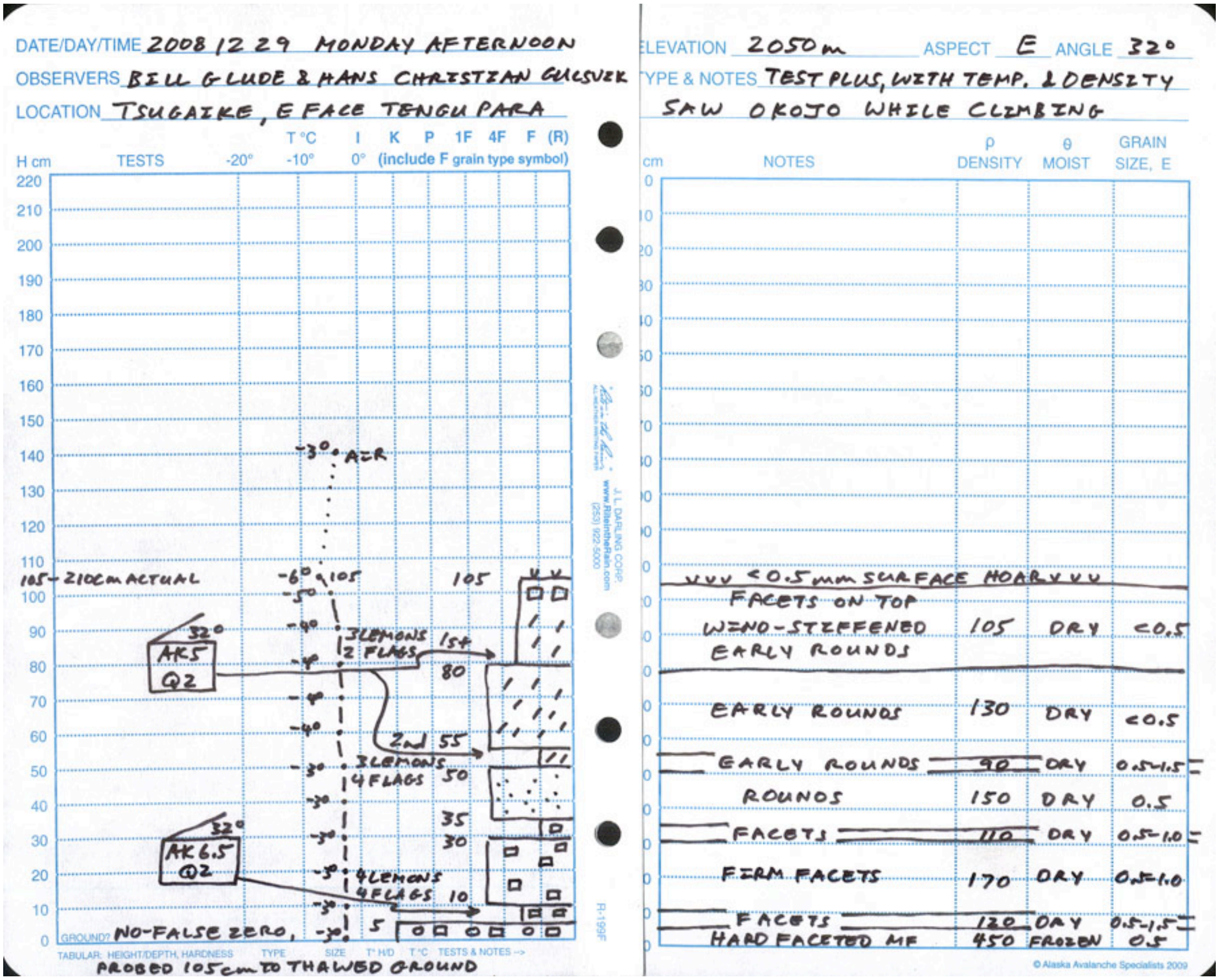


- *Temperature* - In degrees Celsius, from a shaded thermometer, ideally 1.2 to 1.4 meters above the ground. Note 24 hour maximum and minimum if available.
- *Sky condition* - Clear, few (up to 25% cloud cover), scattered (up to 50%), broken (more than 50% but less than 100%), overcast (100%), or obscured (can't see sky due to fog, smoke, or other cause). Obscured is a poor choice of terminology, but unfortunately is standard. Use plain language to clarify whether fog, smoke, or whatever else is causing the sky to be obscured. The sky symbols are listed here and in the fieldbook key pages.
- *Precipitation type* - No precipitation, rain, snow, mixed rain and snow, graupel, or freezing rain.
- *Precipitation rate* - Note rate of snow (or rainfall) in centimeters (or millimeters) per hour. Can be estimated fairly accurately in the field.
- *Wind direction* - By the direction the wind comes from - N, NE, E, SE, S, SW, W, NW.
- *Wind speed* - Estimate average and maximum. We record in meters per second (m/s), which happens to be half of knots, up to 60+ knots, where it is off less than our margin of measurement error. So it's easy to estimate in places like Southeast Alaska where all our anemometers read in knots. Check and calibrate your estimates against weather stations as often as you can.

  - *Precipitation intensity* - Not usually measurable in the field, this is the water equivalent of the snowfall rate, requires density measurement but could be estimated by a seasoned observer. Not really practical for backcountry observers.
  - *Snow level* - This is not a standard observation, but we find it very useful to record the snow level. We record in meters (feet/3.281). If the level is changing, try to estimate the range and trend, if any.
- *The seven signs of instability.* Originally listed by Fesler and Fredston, these are some of the most important observations you make every day in the field. Their absence is as important as their presence, write none if they were not present. If they were present, note any pertinent information
  - Avalanche activity.
  - Whoompfing.
  - Hollow sounds.
  - Shooting cracks.
  - Recent heavy snow.
  - Rain or thaw.
  - Wind loading.
- *Slope and traveling tests* - Did any of the slopes you cut or rode produce any signs of instability, or slides? These are recorded as SCN for slope cut with no result, SCW for whoompfing, SCC for shooting cracks, SCS for slab avalanche, SCL for loose snow avalanche. How steep were the slopes tested? These are NOT your block tests from snowpits, but are the quick ski cuts and other traveling tests you do without taking your pack off or pulling out a shovel.
- *Pits, tests, structure* - You can optionally summarize your snowpit test results here.
- *Evaluation* - This is a summary of the current snowpack conditions. Be careful what you write here. If you are posting your observations on the web, **do not include an avalanche danger level or any other descriptor of snow stability**. Forecasting is only for professional programs with the funding for the daily field presence that is necessary for reliable forecasts. Stick to verifiable facts about the snow. We have provided several lines for Stability Wheel evaluations on the + (tending toward stability), 0 (neutral), and - (tending toward instability) scale. You can summarize on each line by aspect, elevation, windloaded/non-windloaded, or whatever other patterns you see.

Filling in the Second and Third pages - General Notes and Graphic Snow Profile Notation

- The basic idea here is that you are making a sketch of what you have found, so you can recognize the patterns in the field for your own decision-making, communicate what you found to others, and remember it later. You are drawing the wall of your profile pit. The harder layers stand out, just as they do in a brushed pit wall, and the symbols we use for the principal snow types mirror their appearance.
- Rough in your field sketch in pencil. Ink it over with waterproof ink and clean it up during breaks or at the end of the day, and then erase the pencil lines. If you're really rushed, or the weather is too bad to write at all, you can make careful mental notes and write it up later, or record verbal notes with a mini-recorder. Remember that your notes are the legal record of your decision-making. They won't count in court if they are only in your head.
- In the field, follow the step by step outline for studies listed in the first key pages, the Stability Evaluation Roadmap.



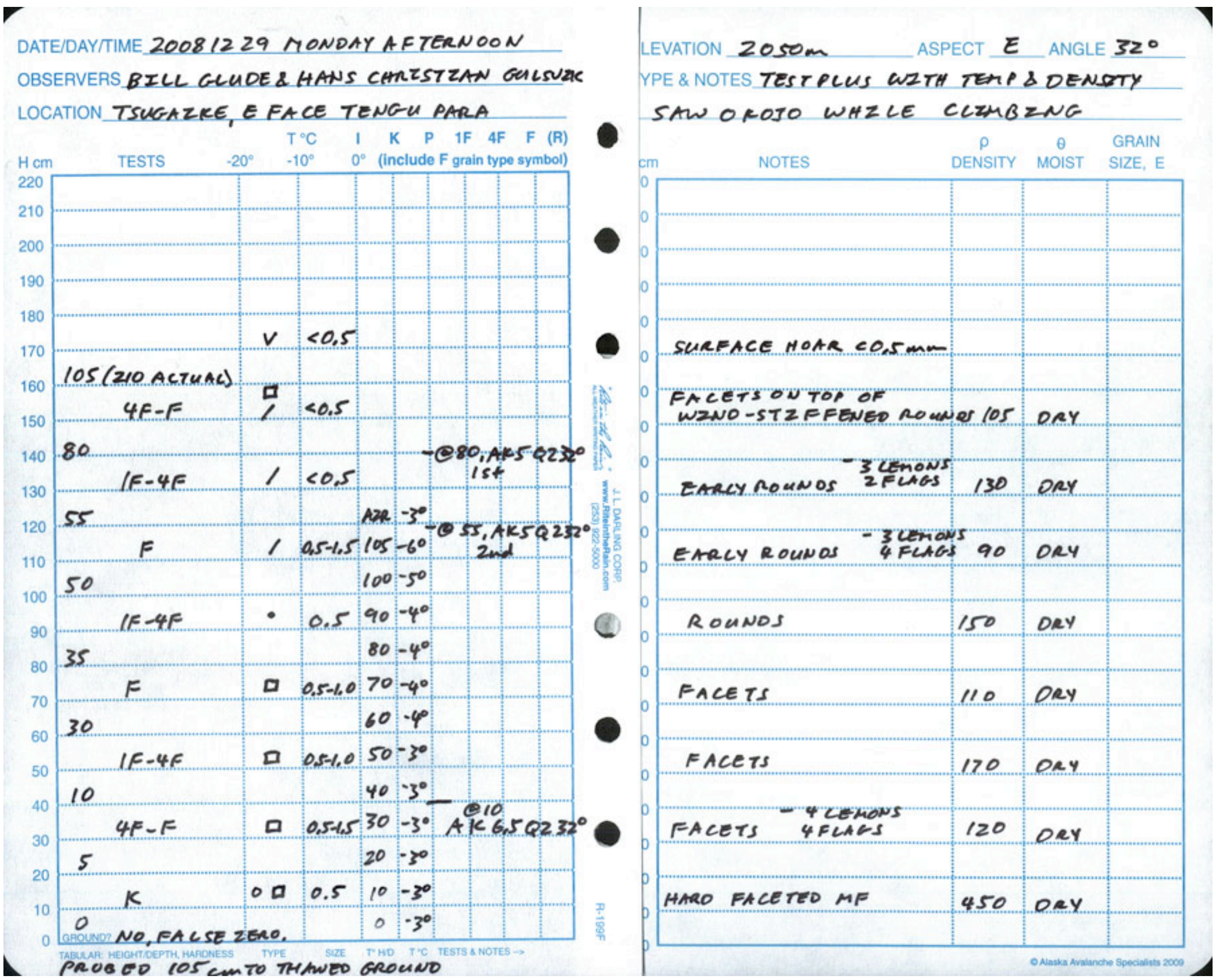
- If you can't reach or probe to the ground, set a false zero at the bottom of the pit and note it as such. If you are recording for official or research purposes, use a graduated probe or other scale to measure the layers. If not, you can use your body for a convenient estimated height scale that's always with you - measure where 50 cm, 1 m and 2 m are on yourself, then stand and mark the meters and half meters on the pit wall for easy reference.
- Our preprinted fieldbooks have a snow height scale from 0 to 220 cm, as deep as most people are likely to dig. Use two pages if you go deeper. We find the false zero method is the simplest to set up accurately, but provided a top-down scale on the right-hand side for those who prefer it.
- To begin, follow smoothing and brushing with the hand hardness test ("poke it" in the Quick Pit Chant) to pick out the layer breaks. Sketch them in by their height and hardness. Note the height of each layer break right next to it on the sketch. Extend the layer break lines carefully across onto the right page so it is clear which notes go with which layers.
- If you are taking temperatures, start them while you are doing this. Pull out a hand lens and do further tests to identify and characterize the layers as necessary.
- *Hints on how to break out the layers*
    - Describe the snowpack in as few layer groups as possible to start with. Be sure your written profile calls out all these breaks.
    - Add in the other layers that reflect the structurally significant weather events.
    - You do not need to pick out every layer you can detect. You can group the layers into patterns:

    - "alternating wet snow and melt forms" (created by rain-snow-rain-snow in warm storms)
    - "alternating 4 finger windloaded new snow and fist new snow (created by wind and density fluctuations within a single storm event),
    - or "finely laminated windslab" (typical density and bonding differences in hard windslab)
  - You do need to pick out the major shear planes. Write up the profile, do the block tests, identify the weaknesses, and add the shear layers if you didn't pick them out already. Weak bonding may not be visible or otherwise detectable until you do block tests.
- Slope or curve the hardness lines if you need to indicate gradations in hardness. Offset them slightly to show small but significant differences. Remember, this is a sketch of what you see, you can indicate subtleties with the graphics that alphanumerical tabular recording won't allow.
- Write the heights by the layers on the graph so you have accurate numbers for them rather than relying on reading your sketch.
- Fill in the symbols for snow types inside the hardness bar graph on the left page as you go. Call the layers out by their dominant grain type. Go by structural significance if the grains are borderline. Mix symbols as appropriate to sketch what you see, principal form first and secondary second.
- We use the basic international snow symbols for all the classes, plus a few key subclasses. Most of these symbols are intuitive simplified drawings of how that form actually looks. Refer to the key pages for the symbols. We have carefully picked out the key symbols you really need.
- There are more subclasses in the official IACS snow classification scheme, but they are hard to remember, harder to draw in the field, often misidentified, and usually unneeded to describe what you find. If you go farther into the subclasses, always list the symbols for the major classes first, then add the subclasses with a written label so your profile is easily understood. Start with these symbols. You can use -> arrows to indicate changing types or the / symbol to indicate one type grading vertically into another.
- Put written layer descriptions on the righthand page. Use early, intermediate, and advanced to describe rounds and facets more accurately. Add whatever other notes you need to describe what you see.
- Our forms have density, moisture content, and grain size columns to the right of the note space, with the most commonly used ones at the far right, so you can write over any columns you are not using. Add moisture and grain size, if you are noting them, as you fill in the layers. Add densities for key layers as you take them, if you are doing densities.
- Measure temperature in a shady portion of the pit, and use a shovel stuck in the snow to shade the near-surface layers if it's sunny. Cool the thermometers by inserting them in the snow before taking temperatures. The official procedure for the best accuracy but necessary only for thermometers far more accurate than any we use, is to insert them in the same layer, then move them over to a fresh location in that layer.
- Note that the sensor may be in a layer below the insertion point on a slope, and compensate accordingly. It is best to take temperatures on a side wall to avoid height error.
- For the most accurate surface temperature, hold the dial in a gloved hand and swish your shaded thermometer slowly through the surface layer. Laying it on the surface as described in SWAG is not as accurate.
- Calibrate your thermometers in a freshly stirred slush mixture of ice and water at equilibrium, which will stay exactly at 0ºC. Dial stem thermometers are easy to calibrate, twist the stem to adjust them.
- Temperature is plotted just left of the profile. Write the value next to the dots on the plot. Take temperatures on even ten centimeter intervals (or multiples) for easy plotting and calculation. Intervals can be 40 cm or more near the bottom of deep pits where temperature variations are virtually nonexistent, but should step down to 20 cm and finally 10 cm intervals near the surface or in other areas with temperature variations.
- The preprinted scale on our forms goes from 0° to -20°C, but you can scratch those values out and write in 0° to -10°C or 0° to -40°C if that suits the range you have. Connect the measurement points

with a dotted or dashed line, note the surface temperature, and plot in the air temperature above the snow.

- Indicate block test results by an arrow on the left side of the profile pointing to the fracture layer. Include the type of test, its numerical value, the slope angle, tester weight, block size, and any other necessary parameters. Note the depth the shear block was dug or cut to on the height scale.
- Use a "Jack in the Box" graphic as shown on the key pages and sample notes for shear tests, with the abbreviation for the type of test and its value along with the shear quality inside. The slope angle is indicated under the "lid" of the box. You can optionally note aspect to the left of the box, elevation and tester weight on the right, and the height and type of the weak layer and slab below it. Jack in the Box notation also works well on an altitude-aspect rose diagrams.
- Note the weather events that created the layers or groups of layers, and their dates, where possible, in the text area on the righthand page.
- Add other notes, experiments, or anything else that may be helpful.

Filling in the Second and Third pages - For Alphanumerical Tabular Snow Profile Notation



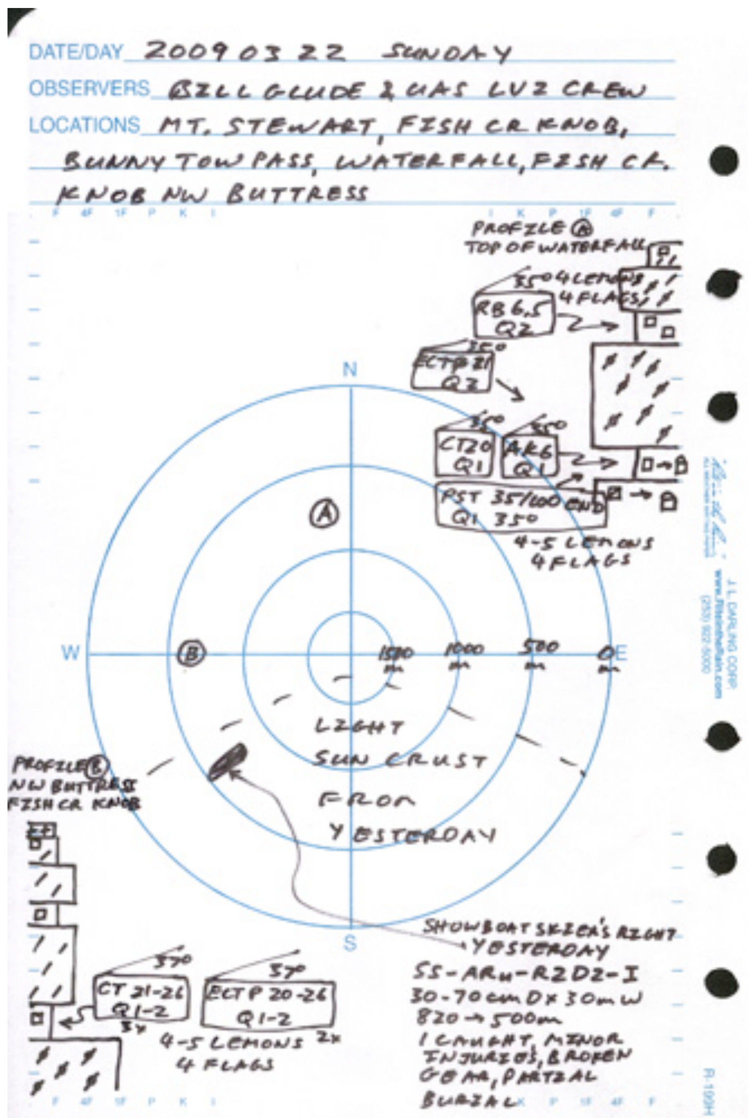
- Our fieldbooks are oriented primarily to make graphical recording easy, but you can use them for tabular recording too.
- The small column labels at the bottom of the lefthand profile page are there for tabular notation.
- Note height of layer breaks on every other line. Write the characteristics of the layers between those breaks on the lines between their heights.

- There are columns for hardness, grain type, grain size, and temperature.
- There is a column for a temperature height scale and one next to it for the readings.
- Tests and notes go to the right of the layers.

Filling in the Fourth Page, Extra Note Space

- In leadership situations, you should have a party member list, with medical and other notations as necessary, in your fieldbook. This can be on the fourth page or on a regular level page.
- For heliskiing, you will need a log section with Hobbs readings, flight times, list of runs on the fourth page or on a regular level page.
- You can record experimental data or sketch avalanches you are investigating here, too.

Filling in the Aspect-Elevation Rose Pages



- We now have daily pages with the observations format on the front side as used for the profile pages, and an aspect-elevation rose diagram on the back side.
- These pages are well-suited for days when you are sampling quickly and widely rather than doing one or two more-detailed test pits, and are great for compiling observations from a number of fieldworkers.
- Set up the elevation scale for whatever makes sense for the elevation range you are working in.
- There are scales and tick marks for up to four quick profile sketches in the corners. Connect them with numbers or arrows to relate them to the elevation and aspect they represent.
- Use Jack in the Box diagrams for test results.
- Note avalanche activity, wind scouring or loading, freezing elevation, surface hoar distribution, or any other patterns you observe on these diagrams. Bruce Tremper's *Staying Alive in Avalanche Terrain* book has an excellent section on using rose diagrams that we will not attempt to duplicate. Read what Bruce has to say and study his examples.
- These rose diagrams are great for compiling observations from several field groups, or for keeping a daily log of observations for a guiding operation.

Useful things to have written or copied and taped into the front or back of your fieldbook

- You can pull your notes from loose leaf books every so often, so you don't lose as much if you lose the book. Keep them filed in a safe place.
- Crevasse rescue hauling systems, equalizing anchors, knots, and emergency radio information.
- Field maps for key areas. We scan and Photoshop them up to scale and size, and color copy them onto waterproof paper for our own books.