ALTERNATIVE RISK MANAGEMENT; FAT MAN, LITTLE BOY AND THE WINCH ROLLER

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ABSTRACT: "Slope compaction and deep slab instability; alternative avalanche risk management." In recent years, ski area expansion into 'extreme' avalanche terrain has become a perceived necessity in order to remain competitive in a flat or declining market. Inclusion of such terrain increases the demands on the avalanche control programs and frequently calls for creative or alternative means to effectively manage the increased risk. Slope compaction has been used for many years as an effective means to reduce depth hoar formation and improve snow cover stability. Catastrophic failure of the Dynamo ski slope in March 1995 helped produce new and creative avalanche countermeasures for risk management.

KEYWORDS: Snow compaction, snow cover stability, avalanche countermeasures, snow vehicles.

1. INTRODUCTION

Early season snow compaction has been used for years as an avalanche countermeasure to alter the snow cover structure, increase snow strength and improve snow cover stability. This early season snow compaction is of particular importance in a continental snow climate characterized by a shallow and faceted snow cover structure. Traditional techniques for snow compaction have included machine grooming on gentle terrain and salting of race courses. Boot packing and ski packing, in conjunction with skier traffic have also been used to achieve snow compaction on steeper avalanche slopes. On one such slope, the Dynamo, inadequate early season snow compaction combined with the inability to perform effective explosive control measures resulted in complete slope failure. The class 5 hard slab "design" avalanche that resulted caused the realignment of a proposed lift as well as practical changes in the avalanche countermeasures being used.

2. BACKGROUND

The Dynamo (see Figure 1.) is a large, open west to northwest facing avalanche slope near timberline. The top elevation is 3,731 m (12,242 ft.) Vertical fall is 450 m (1500 ft.). The large open upper face averages 30 to 35 degrees and drops over a 45 meter (150 ft.) cliff band mid-slope. The northern flank is a series of steep, 37-45 degree, narrow and rocky couloirs. Prevailing southwest winds cause side loading and slab formation. Snow cover is usually shallow, 1-3 meters, and well faceted.

Prior to the mid 1980's the Dynamo was within the U.S.F.S special use permit area but beyond the operational boundary of the Telluride Ski Area. As a result of a near fatal "out-of-bounds" avalanche accident and increasing public pressure the Dynamo and several adjacent avalanche paths were included in the operational boundary.

When the avalanche terrain on Gold Hill was first opened for hike up skier access the Dynamo remained closed. Little or no early season packing was budgeted for. Adequate increases in staffing levels were not budgeted for. Inaccurate or difficult avalauncher targeting of lower release zones in the steep northside couloirs and exposure to the mid-slope cliff bands made hand charge routes on the Dynamo very dangerous. Eventually, budgets were increased to allow more early season packing and increased staffing. More knowledge of the terrain and experience with the avalauncher was gained before the Dynamo was cautiously opened to the skiing public.

During the '93-'94 winter season a long, crude, polypropylene rope and wood tramway was constructed to try and deliver explosive charges to the lower release zones on the northside gullies. A permanent closure remained mid-slope where the main face of the Dynamo benches above the cliffs.

3. 1994-1995 WINTER SEASON

The Colorado high country saw snow start to accumulate during early October. The new snow cover on the Dynamo was ski compacted prior to the end of the month. Attending ISSW '94

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at Snowbird, patrol first aid training and preperation for a early pre-Thanksgiving opening provided little time for more ski compaction until late November. During that time, 38-46 cm (15-18 inches) of low density new snow had fallen. Before ski compaction could resume the wind had created a wind slab on top of the new snow. Gold Hill was opened to the public in early December as snowfall resumed. The Dynamo Face sees fewer skiers than other Gold Hill runs because it is interrupted by the mid-slope cliff closure and is more subject to wind slab formation. Hike-up skier traffic on the Dynamo Face was not sufficient to break through the wind slab and disturb the low density November snow layer below. This layer developed into sharply faceted grains as skiers continued to rearrange the snow cover structure above.

4. MARCH 1995 STORM

In the 10 days between Feb 25 '95 and March 7 '95 Telluride received 77.0 inches (196 cm) of new snow with 5.72 inches (145 mm) water equivalent. (See Table 1.) The storm broke mid-morning on the 6th after 21 inches (53 cm) of new snow overnight. The third avalauncher round landed in uncompacted snow in the mid-slope cliff band. It triggered an avalanche fracture along the horizontal closure below the main Dynamo Face. With support at the stauchwall removed, the entire Dynamo Face suddenly wrinkled and exploded down the slope. The class 5 hard slab avalanche had a crown 3 meters deep, 150 meters wide and ran over 500 vertical meters. Ski packing tracks from early October remained clearly visible on the bed surface. The thin weak shear layer was comprised of faceted grains that metamorphosed from the uncompacted low density November snowfall.

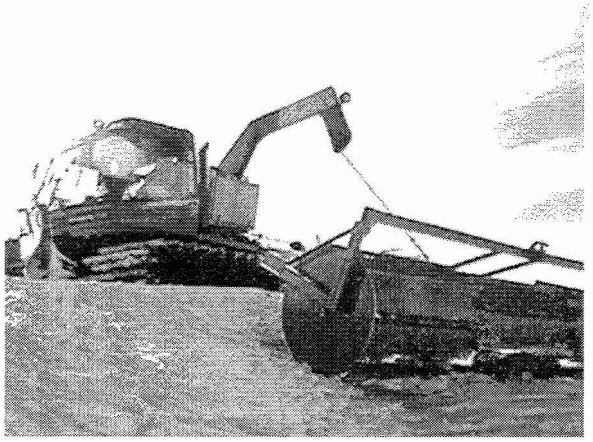
5. THE RESPONSE

The March 6th Dynamo avalanche was apparently the result of weakness from incomplete snow cover compaction and substantial new snow load from a major storm event. This "design" avalanche ran full depth, full width and full length. It overran a proposed lift alignment and would have killed any patrollers running hand charge routes mid-slope or in the northside gullies. In response; the proposed lift was realigned to a safer location, staffing levels were increased, two new explosive tramways were installed to make the hand charge routes safer and snow cover compaction as an avalanche countermeasure was improved through creation and use of the Winch Roller.

6.FAT MAN AND LITTLE BOY

Two new explosives tramways were constructed in order to improve the effectiveness and safety of the hand charge routes. They were fabricated using 3/16 inch (5 mm) stainless steel cable, steel snowmaking pipe and chairlift sheave wheels. "Fat Man" is the longer tram spanning over 1000 ft. (330 m) and running diagonally downslope through the lower release zones of the northside gullies. "Little Boy" spans 500 ft. (165 m) horizontally through the mid-slope cliff area. Each tram has a hand operated, chain driven, closed cable loop that carries a traveling car and tag line for precise multiple shot placements. Shots are double primed 5 lb. (2.3 kg.) cast pentolite boosters suspended 1 meter above the snow surface. Both trams have proven to be extremely effective with nearly 90% of the shots to date having triggered avalanches.

8. THE WINCH ROLLER



In addition to increased staffing for early season ski & boot packing, a new tool for snow cover compaction was developed. The Winch Roller is simple and effective. And old culvert-like drum roller (used for slope grooming before tillers) was retrofitted with 2 inch (5 cm) angle iron grousers and a new yoke that attaches to the winch cable on a Pisten Bulley snowcat. Using the cable and the hydraulic wings on the plowblade the cat operator can pick up the roller and maneuver to the top of the mountain. He then compacts the snow cover in the avalanche release zones by lowering and raising the roller with the

winch cable as if painting a giant wall. A spotter is used to radio the cat operator directions as he looses sight of the roller on the steep slope below. Compaction with the roller is very fast and effective. In fact, the Winch Roller has proven to be so successful that it is now beingused during the early season to compact other non-avalanche slopes previously packed by the snowcats. It is faster, causes less wear and tear on the snowcats and doesn't tear up the shallow snow cover. The angle iron grousers help break through wind crusts and leave a rough bed surface for good bonding of subsequent snow layers. Several small avalanches have been triggered while using the roller but to date NO avalanches have occurred in any of the snow layers compacted by the Winch Roller.

9. MARCH 1998: THE TEST

In the nine days from March 26,'98 to April 3,'98 Telluride received 82.6 inches (210 cm) of snow and 6.28 inches (160 mm) of water equivalent. (See Table 2.) March 1998 was the third snowiest month on record in Telluride. More snow and more water accumulated in less time than during the big storm of '95. The avalanche cycle in the backcountry was as large as the 1995 cycle that took out trees 212 year old trees. No avalanches occurred on the winch rolled terrain and the new "bomb" trams permitted safe and effective explosive control work to continue throughout the storm cycle. As a result, all of the Gold Hill avalanche terrain remained open for hike-up deep powder skiing...and it doesn't get much better than that.

Table 1. MARCH 1995 STORM

Date	Weather	T (F)	T (C)	HS (in)	HS (cm)	HN (in)	HN (cm)	HNW (in	HNW (mm)	Density	kg/cu.m
2/26/95	snowing-	19	-7	63	160	1	3	0.15	4	15%	150
2/27/95	snowing-	16	-9	63	160	1	3	0.15	4	15%	150
2/28/95	snowing-	19	-7	65	165	3	8	0.2	5	7%	67
3/1/95	snowing-	19	-7	75	191	11.5	29	0.82	21	7%	71
3/2/95	snowing-	19	-7	83	211	13	33	1.1	28	8%	85
3/3/95	snowing+	21	-6	86	218	8	20	0.35	9	4%	44
3/4/95	snowing-	21	-6	87	221	13	33	1	25	8%	77
3/5/95	snowing-	19	-7	86	218	4	10	0.3	8	8%	75
3/6/95	snowing-	16	-9	102	259	21	53	1.5	38	7%	71
3/7/95	clear	0	-18	99	251	1.5	4	0.15	4	10%	100
Averages		17	-8	81	205						
Totals						77	196	5.72	145	7%	74

Table 2. MARCH 1998 STORM

Date	Weather	T (F)	T (C)	HS (in)	HS (cm)	HN (in)	HN (cm)	HNW (in	HNW (mm)	Density	kg/cu.m
3/26/98	snowing-	25	-4	64	163	0.1	0	0.01	0	10%	100
3/27/98	snowing-	20	-7	76	193	14	36	1.55	39	11%	111
3/28/98	snowing-	16	-9	77	196	4	10	0.37	9	9%	93
3/29/98	snowing-	5	-15	86	218	16	41	1.65	42	10%	103
3/3/98	p.cloudy	2	-17	84	213	0.5	1	0.05	1	10%	100
3/31/98	snowing-	8	-13	94	239	13	33	0.55	14	4%	42
4/1/98	p cloudy	19	-7	84	213	5	13	0.25	6	5%	50
4/2/98	snowing+	8	-13	98	249	17	43	1	25	6%	59
4/3/98	clear	16	-9	102	259	13	33	0.85	22	7%	65
Averages		13	-10	85	216						
Totals						82.6	210	6.28	160	8%	76

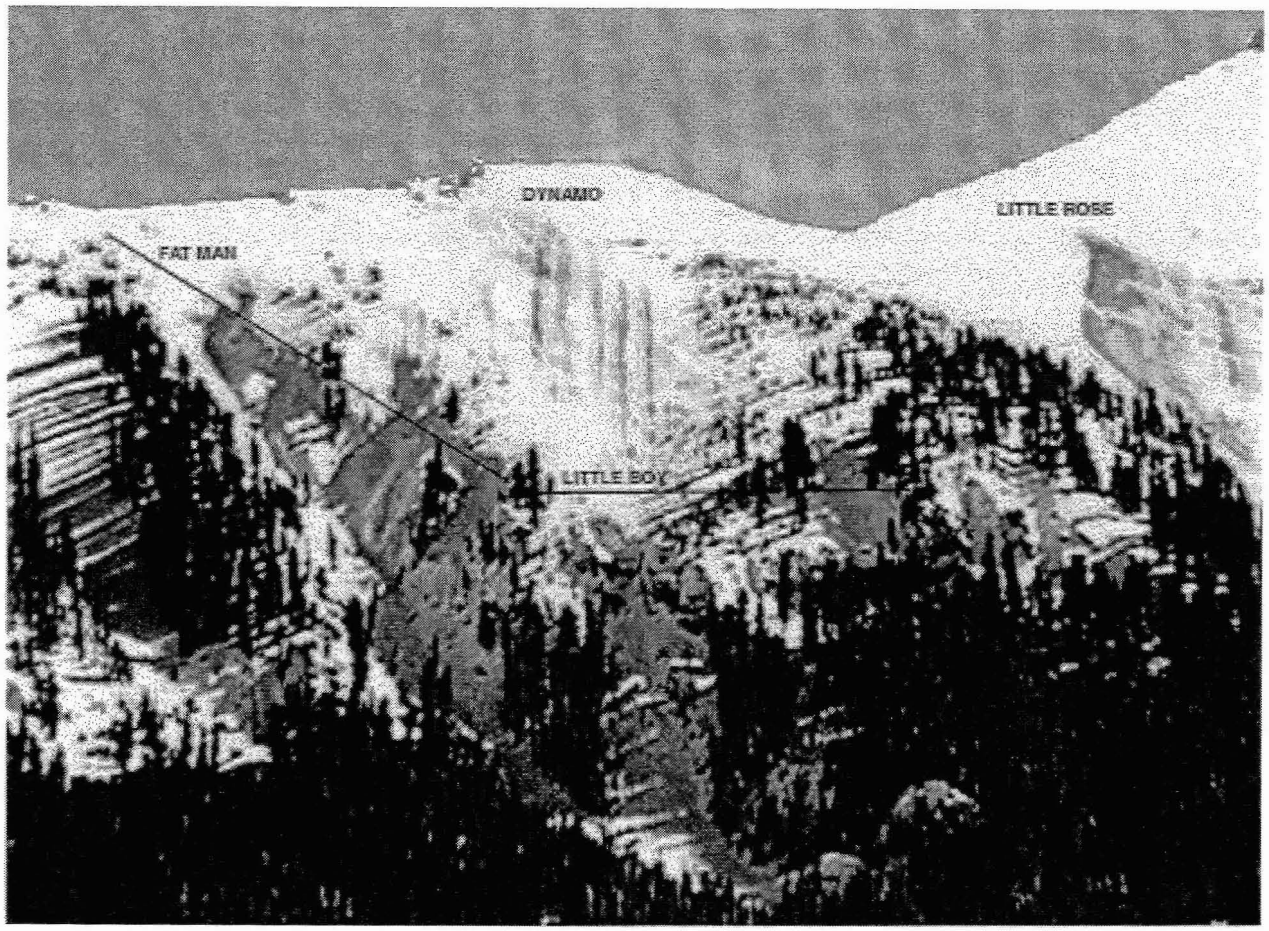


Figure 1. Gold Hill ski terrain at Telluride. Note fresh furrows on Dynamo from recent Winch Roller work. Both explosives tramways are detailed.