2007 WINTER AVALANCHES ON THE KEMANO KITIMAT POWERLINE

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ABSTRACT: 2006-2007 was a 100-year winter on British Columbia's North Coast. Forty of seventy-two towers in Powerline Pass of the Rio Tinto Alcan Kemano-Kitimat powerline, completed in 1954, are exposed to destructive avalanches. On March 28th a storm deposited over 100 mm of precipitation in 24 hours resulting in several large destructive avalanches. Tower 113R on the south side of Powerline Pass was destroyed for the second time in 15 years. Ten kilometers to the south an avalanche in path Ke 8 jumped from its usual track into the adjacent Ke 9 path clearing a swath of mature timber down to the defensive splitter at Tower 39. This paper will describe the destructive effect of large, long return period avalanches and the reconstruction project which required an intensive program of hazard evaluation and avalanche control.

KEYWORDS: Avalanche control, mitigation, return period.

1. INTRODUCTION

The objectives of this paper are to describe the destructive avalanches on the Kemano-Kitimat powerline during the winter of 2006-2007 and the avalanche mitigation for the reconstruction project.

This was a 100 year snow winter in the area. On the night of March 28, 2007 a large destructive avalanche destroyed Tower 113R. A second avalanche in the Kemano Valley spread from its usual track and descended the adjacent path, destroyed a wide swath of mature timber and split around the defenses at Tower 39.

2. LOCATION AND FACILITY PROTECTION

The Kemano Kitimat powerline extends over 80 km from Kemano to Kitimat, BC. This powerline provides power to the Rio Tinto Alcan aluminum smelter.

Forty of seventy-two towers in the Powerline Pass section are exposed to destructive avalanches. Facility protection includes duplicate circuits, overhead suspension by cross valley catenaries, earth and wooden splitters, diversion berms, channel excavation, reinforced towers, avalanche breakers and modified conductor hangers. Observation patrols are used to track the avalanche occurrences and effect of the avalanche defenses.

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Figure 1: The powerline location in the North Coast Mountains of B.C.

2.1 Consequences of power outage

If power to the aluminum smelter is lost for several hours the aluminum "freezes" in the pots. A very expensive start up and refurbishing is then required as the aluminum has to be jack-hammered out of the pots. Due to the potential impact of this scenario Alcan placed a second transmission circuit alongside the first in the high hazard areas and on the same towers in low hazard areas. In this way, as long as only one side of the parallel circuits is lost power still gets to the smelter. As the second circuit is not used by the smelter except in emergencies, it now provides surplus power to the BC Hydro power grid.

Therefore if either of the lines are lost, significant financial loss will be incurred. (Flavelle & Mackenzie, 1996)

3. HISTORY

The Kemano Kitimat powerline line was first surveyed in 1951 and completed in 1954. During the first winter of operation five towers were destroyed in Glacier Creek. An overhead caternary was built the following summer to suspend the line and defend against avalanches.

Thus began a long history of destructive avalanche events and construction of avalanche defenses for the transmission structures. Further damage to towers was recorded in 1957, 1973, 1985, and 1992.

Marcel DeQuervain brought much needed expertise from Switzerland to the project from 1951 through 1978, evaluating the hazard to the structures and providing recommendations for structural protection. Peter Schaerer continued this work into the 1980's. Over time the design heights for the earth splitters were raised to heights ranging from 10 to 22 m in recognition of the snow climate and the potential avalanche flow depths (Schaerer 1985).

Following the loss of Tower 113R in 1992 an active avalanche control program was used to protect the reconstruction team (Flavelle and MacKenzie 1996).

4. SUMMARY OF EVENTS DURING 2007

4.1 The Avalanche of March 28, 2007

The avalanche of March 28, 2007 which destroyed Tower 113 Right (T113R) was a Size 4.5 dry slab avalanche which started on the southwest-facing slopes of avalanche path GC4 (Glacier Creek #4) (Figure 2). The top of the starting zone of the GC4 path (1800 m elevation) is approximately 420 m above the tower. The average incline of the starting zone is approximately 41º. The avalanche dynamics were those of a fast moving, mixed motion avalanche (combined flow and powder), which overran the knoll in the terrain on which T113R sat.

Estimation of the speed of the avalanche is uncertain given the lack of direct observations at the time of the event. However, estimates of the maximum velocity (McClung and Schaerer, 2006) and application of the PCM model (Perla et al., 1980) to estimate velocity in the starting zone suggest the velocity of the avalanche could have exceeded 50 ms^{-1} at T113R.

The wind during this storm appeared to be from the west and would have been channeled through the pass from the northwest. This would result in wind transport of snow from the north side of the pass into and across the starting zones of the avalanche paths on the southwest facing slopes of GC4, above T113R. When the avalanche occurred it appears that the fractures extended from Powerline Pass across both the GC4 and GC5 starting zones.

Avalanches released from several locations in Glacier Creek during the March 28 avalanche cycle. It is notable that the tip of the avalanche deposits from Glacier Creek crossed the Kemano River (a vertical fall of 1580 m, over a horizontal distance of 4600 m). If the combined events in Glacier Creek occurred at the same time this would be classified as a Size 5 avalanche.

4.2 Snow and Weather Conditions

Manual snow survey data has been collected at Tahtsa Lake since 1952 (54 year period). This station is located 35 km southeast of Powerline Pass. The measurements taken on March 28, 2007 are a snowpack depth of 457 cm and a snowpack water equivalent of 1800 mm. These are the maximums recorded for the end of March (recorded as of April 1) in that 54-year period. The same maxima are true for the May 1, 2007 observations of 438 cm and 2073 mm. By applying the method of moments (Watt, 1989) to analyze the data it can be concluded that the 2007 data represents a 100-year return period in snowpack accumulation (i.e. an annual probability of 0.01).

Figure 3 illustrates the data from the Tahtsa Lake snow pillow for the 2007 winter. These snow pillows measure the water equivalent of the accumulated snowpack. The rapid accumulation of snow water equivalent at the end of March stands out in the 2007-year plot (the upper line on Figure 2).

The British Columbia Ministry of Transportation maintains weather stations at valley, mid and high elevations along the Skeena River (Highway 16). Some of the sensors on these stations became buried during the 2006-2007 winter and stopped working. This was due to the exceptional snow accumulation during the 2006-2007 winter.

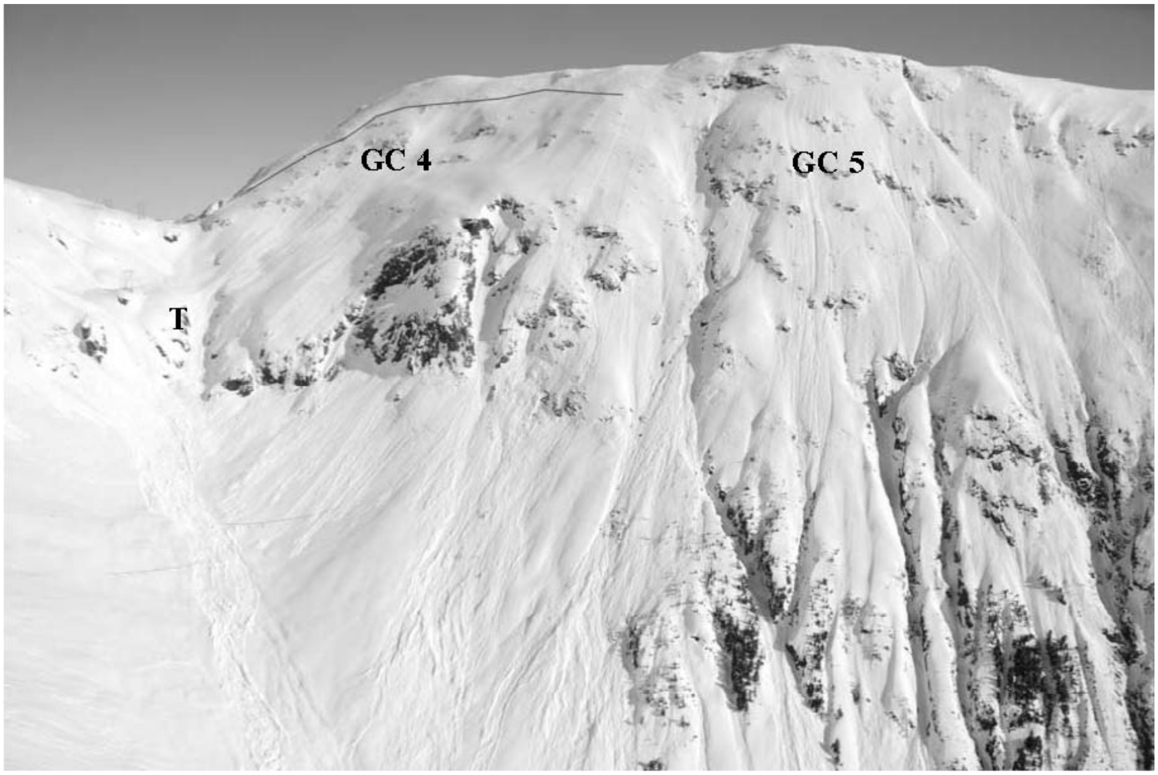

Figure 2: The location of the avalanche fracture line on Path GC4 above the Tower 113 location (T). The fracture lines of March 28 would also extend across GC5.

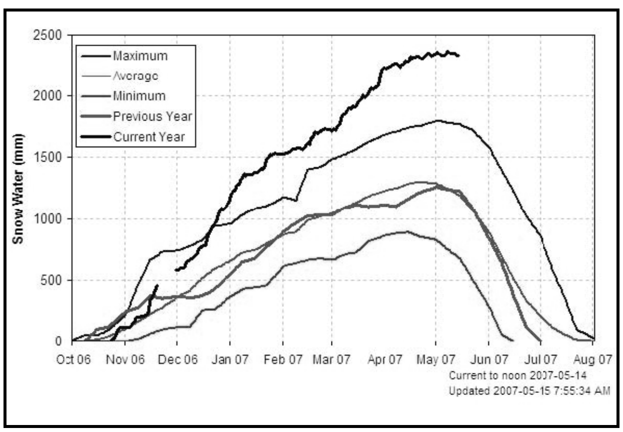

Figure 3: Snow pillow data 2006-2007 Tahtsa Lake (Station 1B02; elevation 1300 m). Source: BC Ministry of Environment, Water Stewardship Division.

Approximately 111 mm of precipitation was observed to accumulate in the 24-hour period of 0800 hours March 28 to 0800 hours March 29 at Salvus Camp (elevation 12 m ASL) in the Skeena Valley. This precipitation came as heavy snowfall overnight on the 28th. It is reasonable to assume that precipitation values at higher elevations would exceed those observed in the valley bottom at Salvus. This precipitation was accompanied by a slightly rising temperature trend, but one where temperatures remained below freezing at the treeline and above.

Moderate (18-38 kmh^{-1}) southwest, west and northwest winds were observed at the Kasiks High (1435 m) weather station during this 24-hour period. The wind station stopped working at 0500 hours on March 29.

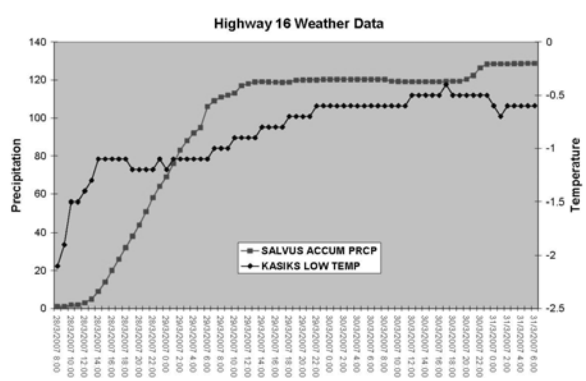

Figure 4: Precipitation data at Salvus and temperature at Kasiks low.

The Kemano climate station observers recorded 82 mm of precipitation on March 28 and

30 mm on March 29. This amount implies a similar trend during the storm at Kemano to that observed at Salvus. Figure 3 shows precipitation data take at Salvus (12 m ASL) and temperature data taken at Kasiks Mid (732 m) during the March 28-29 storm.

4.3 2007 Operational Snow Safety Program

An intensive program of hazard evaluation and avalanche control was implemented to provide site safety during the reconstruction of Tower 113R and for the removal of avalanche debris at the Tower 39 splitter. A framework for providing site safety consisted of development and implementation of avalanche safety protocols and training, avalanche hazard evaluation, and active and passive avalanche control measures.

The development and implementation of avalanche safety protocols and training began in the beginning of April 2007 and was coordinated by Rod Gee (CSA) and Mike Gajda (CSA). At this time a decision was made to have two avalanche technicians responsible for the Tower 113R worksite and an additional technician responsible for the Tower 39 worksite.

Working with Alcan management the avalanche technicians developed an avalanche rescue plan for the work site. In addition to the rescue plan, all field personnel at the work site were provided avalanche awareness and rescue training. Avalanche rescue caches were established at Kemano camp and at Powerline Pass along with an emergency shelter at the Tower 113R worksite.

A daily program of avalanche hazard evaluation was initiated at the onset of the project and was continued until the end of the avalanche season. This daily program began with a morning weather forecast and a forecasted avalanche hazard. On days when weather conditions were forecast to be favorable for work at the Tower 113R worksite a helicopter reconnaissance of the area was completed prior to the arrival of work crews. Regardless of the avalanche hazard, at least one avalanche technician was within the vicinity of the Tower 113R worksite at all times when work crews were present.

During the removal of avalanche debris from the Tower 39 splitter hourly radio contact was maintained with the work crews and an observation post was maintaned at treeline across the valley from the Ke 8/9 avalanche paths. This observation post was typically manned during warm, sunny afternoons when rising temperatures resulted in an increased avalanche hazard.

Figure 5: Split avalanche flow at Tower 39.

Figure 6: The run-up of the avalanche flow at Tower 39 was < 1m from overtopping the splitter.

Avalanche control was extensive for the project and involved a combination of active and passive control measures. Passive control measures involved the construction of a series of benches/berms across the slope upslope of the Tower 113R worksite. This combination of benches and berms were constructed primarily with a Bombardier snow cat along with a D8 cat. These benches/berms provided protection from avalanches originating from the GC3 avalanche path.

In addition to passive control measures, active avalanche control was required to protect work sites at 113R, 114L, the “mini-cat” anchors, under “Cat 1” catenary, the Powerline Pass, the four “Cat 2” anchor locations, all helicopter landing sites and all access routes connecting the above locations.

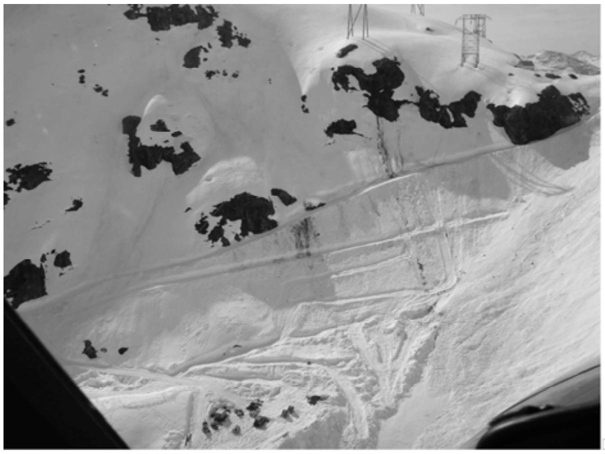

Figure 7: Bench cuts above a cable splicing worksite.

Helicopter bombing was completed on thirty days between April 2 and June 16 using a total of 12,900 kg. of explosives. Results from the control work produced a variety of avalanche sizes and types. Helicopter bombing resulted in 105 Size 2-2.5 avalanches, 20 Size 3 avalanches, and 4 Size 3.5 avalanches. Size 1 avalanches were not included. Avalanches ranged from small, loose snow avalanches to deep slab avalanches with fracture lines to 3m in depth.

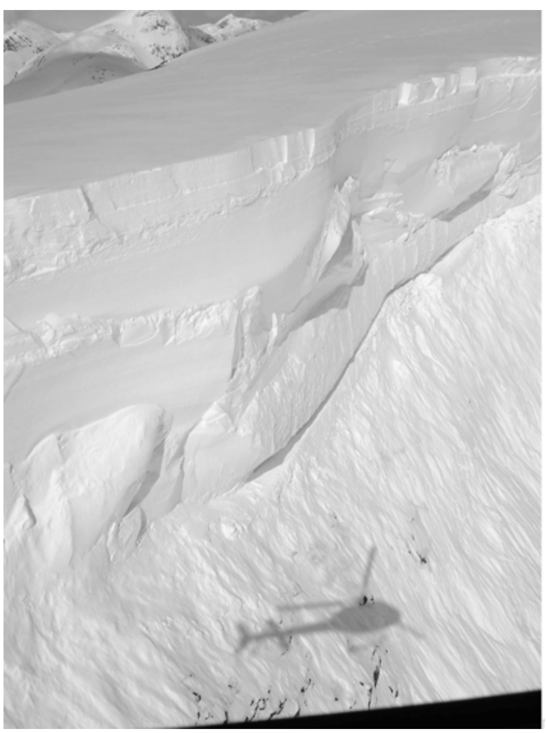

Figure 8: 20 m thick cornice break at GC1.

Extensive glide slabs were also encountered which required large quantities of explosives to release. Typical charges for glide slab work and deep slabs ranged between 250-300 kg of Anfo. Long sections of cornices were also removed, specifically in the GC1 avalanche path.

5. CONCLUSIONS

The following conclusions can be drawn from the 2007 winter experience on the powerline:

- This was an exceptional year for snow accumulation (a 100-year return period for snow accumulation at Tahtsa Lake). The deep snowpack filled and smoothed the terrain, making large avalanches and long avalanche runout more likely.
- Large, long return period avalanches tend to deviate from the normal path and expand path boundaries. Observers should be cautious in applying short term experience in estimating design avalanche potential.
- The precipitation intensity during the storm, which reached 11 mm/hr at the Salvus Ministry of Transportation station, would be a potential trigger for the avalanche.
- The speed of the avalanche below the 41º starting zone could have exceeded 50 ms^{-1} (180 kmh^{-1}) and this high speed of the dry mixed flow and powder would overrun the Tower 113 location.
- Construction in steep, high alpine worksites is possible with extensive avalanche control and acceptance of delay due to weather and hazard.
- Removal of stubborn deep slabs and glide slab avalanches requires reconsideration of conventional winter avalanche control techniques. Charge sizes were increased by a factor of 10 or more to facilitate clearance of slopes above the worksites.

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