Study of snowslides at Bersimis No. 2 Development, Quebec

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No. 284

TECHNICAL NOTE

NOT FOR PUBLICATION — FOR INTERNAL USE

PREPARED BY P. Schaerer CHECKED BY LWG APPROVED BY RFL

PREPARED FOR H. G. Acres and Co. DATE July 1959

SUBJECT Study of Snowslides at Bersimis No. 2 Development, Quebec

The following comments are based on the letter and the enclosed plans sent by H. G. Acres and Company on the 22 June 1959.

From the topography of the hill behind the intake, snowslides may be expected. Snow could slide easily on the steep hillside with 45° or more slope angle. Slides may occur either after heavy snowfalls when the new snow slides on the old surface, or in spring when the melting snow slides on the ground. The gate hoist is close to the mountain and any slide from the slope would hit the structure.

There is no information available on the snow accumulation in this area and there is no information as to whether or not avalanches occur at this place or in the neighbourhood. We do not know if there is enough snow to create snowslides. From published snow observations (1, 2, 3) the following maxima for the snow cover in the Bersimis area may be assumed:

Maximum snow depth: 4 feet
Mean density of snowcover: 0.30 (approx. 20 pounds per cubic foot)
Maximum depth of new snow in one snowfall: 12 inches

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(1) Gold, L. W. and G. P. Williams. Some results of the snow survey of Canada. National Research Council, Canada, Division of Building Research. June 1957. NRC 4389

(2) Williams, G. P. Variability of physical characteristics of snow cover across Canada. Association Internationale d'Hydrologie Scientifique, Union Géodésique et Géophysique Internationale, Assemblée Générale de Toronto 1957. Gentbrugge 1958, Tome IV, p. 158-165. (Reprint NRC 4826)

(3) Pearce, D.C. and L. W. Gold. The Canadian snow survey, 1947-1950. National Research Council, Canada, Associate Committee on Soil and Snow Mechanics, Technical Memorandum No. 21, August 1951.

The wind has a great influence in the building up of an avalanche. With the prevailing wind from the south and west the snow deposit would not be high and not enough snow would accumulate for slides; wind from the north and east may deposit more snow in the slope above the water intake. Only observations in the field could show the influence of the wind on the snow accumulation.

If the above-mentioned deductions on the snowcover and snowfall are correct, then avalanches may be expected.

POSSIBILITY OF AVALANCHES

From the information available, a profile of the avalanche slope was drawn (Fig. 1).

1) A slab of dry, new snow can slide on an unstable internal snow-layer during the winter months.

Maximum depth of the slab: 24 inches
Density of the sliding snow: 0.15

According to Dr. A. Voellmy (4) the avalanche will have a speed of 55 feet per second on the 45° slope. The avalanche would probably get airborne on the top of the niche cut for the hoist; the snow, mixed with air, can hit the structure and the gate at any place above the ground which is in the trajectory. If the avalanche hits the structure, it might have the following dimensions:

Depth:	8 feet
Width:	width of the structure
Density:	approx. 5 pounds per cubic foot
Velocity:	55 feet per second

The pressure caused by this avalanche would have a duration of not more than 10 seconds.

2) On very hot days in spring or with rain, the complete snowcover might slide down on the steep rocky ground.

The following avalanche could be expected:

Depth:	4 feet
Width:	width of the structure
Density:	20 pounds per cubic foot
Velocity:	60 feet per second

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(4) Voellmy, Dr. A. Ueber die Zerstoerungskraft von Lawinen. Schweizerische Bauzeitung, Vol. 73, No. 12, 1955.

This avalanche would follow the ground, might hit the structure on the bottom and might pile up the snow to a height of 23 feet (Voellmy)

Pressure on the gate could be:

$$P_h = \frac{D - v^2}{2\,g} = 1150 \text{ pounds per square foot}$$

D: Density of snow
v: Velocity
g: gravitational acceleration

There might be a pressure in upward direction:

$$P_v = 0.25 \times P_h$$

AVALANCHE DEFENCE

Supporting Structures (Fig. 2)

The slope area above the gate could be covered with supporting structures retaining the snow in the accumulation area. The structures have to be little higher than the deepest snow to be expected.

Distance between structures measured on the slope: 120 feet. The avalanche slope is 700 feet long, therefore 6 lines of structures would be required.

Width of the slope to be covered: estimated 200 feet. Total length: 6 lines at 200 feet, 1200 linear feet.

The structure would have to support a pressure from creeping and sliding snow of 600 pounds per linear foot.

The supporting structures can be fences of steel, timber; a combination of steel and timber, aluminum, prefab. concrete; or nets of steel or nylon between steel or aluminum posts. There are no foundation problems as the structures could be anchored in the rock.

Diverting Wedge (Fig. 3)

A wedge might be constructed above the gate hoist, which would divert the avalanche to both sides. The angle between the avalanche and the diverting dam should not exceed 15°.

The dam of the wedge might be built as a wall of concrete, sheetpiles anchored on rails driven into the rock, or it might be excavated from the rock.

The pressure on the wall from the avalanche might be:

$$P = \frac{D \times v^2}{2\ g} \sin \beta = 1150 \sin \beta \text{ lb p sq ft}$$

β: angle between avalanche and wall

Friction on the wall: $F = f \times P$ — f: 0.70 for concrete, rock; f: 0.40 for metal or wood surface

The following questions would have to be answered before the construction of a wedge is considered:

Will the avalanche do any damage on either side of the gate hoist?

Is the construction of the wedge possible in the steep, rocky hillside?

<u>Roof</u> (Fig. 4)

If the distance is small, a roof might be constructed between the rockface and the gate hoist structure, diverting the sliding snow over the structure.

The roof would have to be designed for the following loads:

1) Static Load from snow and moving avalanche: P: 120 pounds per square foot

2) Dynamic force when the snow is deflected by the roof:

$$P_D = 2\ h\ \frac{D\ v^2}{g} \times \sin\frac{\sigma}{2}$$

h: depth of snow: 4 feet
D: density of snow: 20 pounds per cubic foot
v: velocity of slide: 60 feet per second
σ: angle of deflection

P_D is the force on 1-foot length of the roof.

3) Frictional Load: $F = 0.5 \times$ weight of the moving snow
F: 40 pounds per square foot

The roof would have to be supported by the hoist structure, requiring a change in the design of the structure.

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Based on the above mentioned figures, study can be made as to which defence is the most economical.

Before any consideration is given to the construction of any type of defence the following information should be obtained from meteorological records or from snow observations:

1) maximum snowdepth and density of the snowcover

2) maximum depth of new snow in one snowfall (over a period of three days)

3) prevailing wind, prevailing wind during snowfalls.

In the coming winter, the following observations should be made at the location of the possible avalanche:

1) snowdepth at different points on the hill above the intake

2) accumulation of drift snow

3) avalanches at this place; do avalanches occur on other hillsides in the neighbourhood; if so, what is their location, exposure and slope angle.

Considering the fact that almost nothing is known about the snow and the occurrence of avalanches, it might not be wise to attempt to build any avalanche defence in this summer. Close observations should be made at least during one winter before final decisions are made. Without avalanche protection works, it would be essential to keep the slope above the gate house under constant observation while snow was on the ground next winter.

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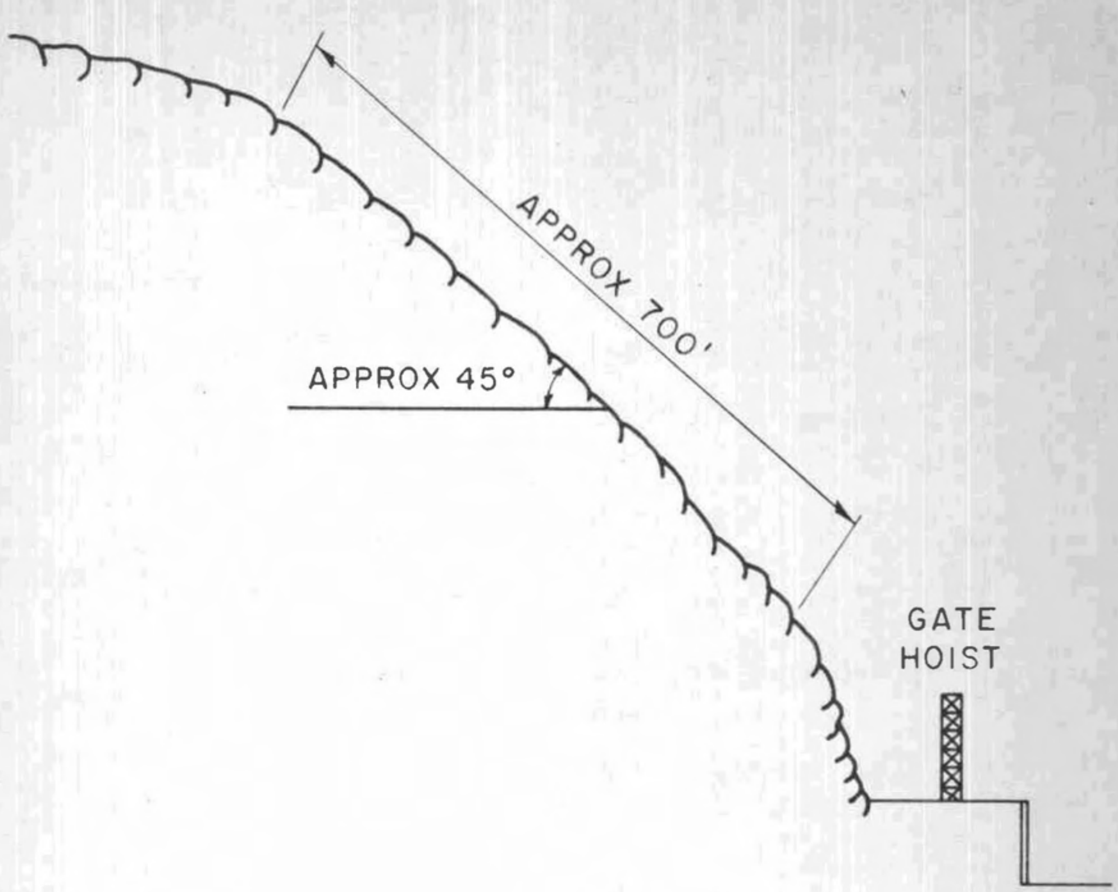

FIGURE 1 PROFILE OF SLOPE ABOVE GATE HOIST

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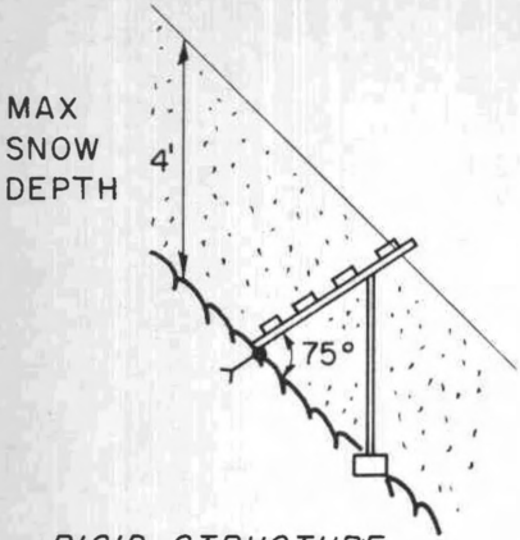
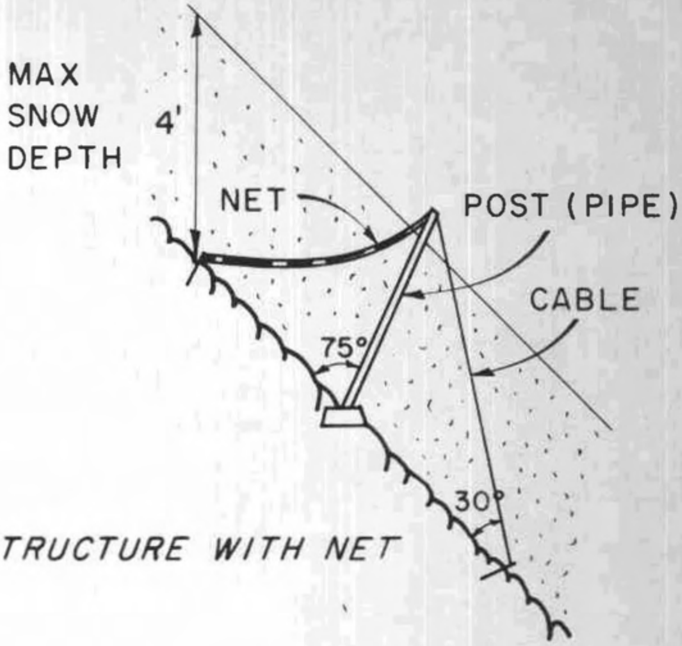


RIGID STRUCTURE



STRUCTURE WITH NET

<u>SNOWPRESSURE</u>

S PARALLEL SLOPE: 600 LB/FT

Q PERPENDICULAR SLOPE: 90 LB/FT

W WEIGHT OF SNOWPRISM

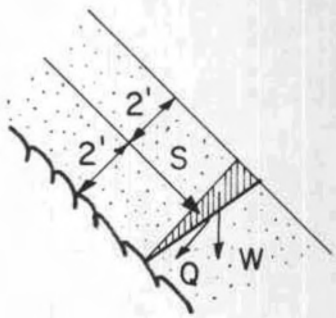


FIGURE 2 SUPPORTING STRUCTURES

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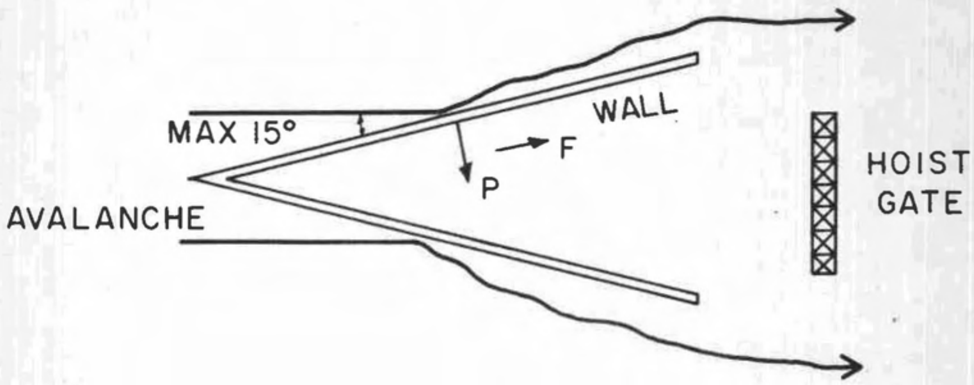

P: PRESSURE PERPENDICULAR TO WALL
F: FRICTION ON WALL

FIGURE 3 PLAN OF WEDGE

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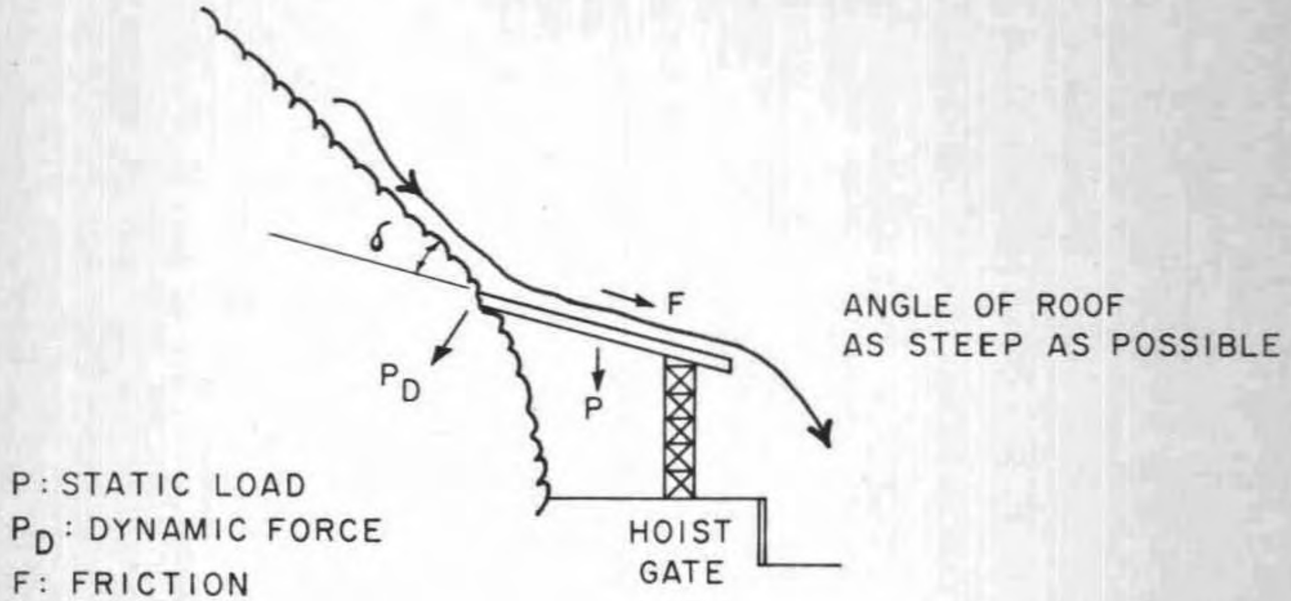

FIGURE 4 SECTION OF ROOF