Journal of Glaciology, Vol. 20, No. 82, 1978

SHORT NOTE ON SLAB-AVALANCHE MEASUREMENTS

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ABSTRACT. From a study of 205 slab avalanches it is concluded that failure initiates where the slope is 25° or steeper, that slab failure stress is in the range 10^2 N m^{-2} to 10^4 N m^{-2}, and that the slab failure plane is most commonly at a temperature of −5°C or warmer. The study also indicates that the shear strength of weak layers varies approximately as the square of the density.

RÉSUMÉ. *Courte note sur les mesures d'avalanches de plaque.* A partir de l'étude de 205 avalanches de plaque, on conclut que la rupture se produit là où la pente est de 25° ou plus forte, que l'effort au moment de la rupture de la plaque est de l'ordre de 10^2 N/m² à 10^4 N/m² et que le plan de la rupture de plaque est le plus souvent à une température égale ou supérieure à −5°C. L'étude montre aussi que la résistance au cisaillement des niveaux faibles varie approximativement comme le carré de la densité.

ZUSAMMENFASSUNG. *Kurze Mitteilung über Messungen an Schneebrettlawinen.* Aus der Untersuchung von 205 Schneebrettlawinen ergibt sich, dass der Bruch bei Hangneigungen von 25° oder mehr eintritt, dass die Bruchspannung zwischen 10^2 N m^{-2} und 10^4 N m^{-2} liegt und dass die Bruchfläche meistens eine Temperatur von −5°C oder mehr besitzt. Die Studie zeigt weiter, dass die Scherfestigkeit weicher Schichten sich annähernd mit dem Quadrat der Dichte verändert.

TABLE I gives results from a recent study (Perla, 1977) of 205 cases of snow-slab failure observed in Switzerland, U.S.A., Canada, and Japan. With reference to Figure 1, the parameters of Table I are explained as follows:

θ, inclination of the bed-surface, typically measured immediately below the crown,
h, slab thickness, measured at the crown centre,
$\bar{\rho}$, mean slab density over the thickness h,
B_{xz}, the approximate shear stress at the bed-surface prior to failure, computed from $\bar{\rho}gh \sin \theta$,
ρ_B, density at the bed surface, typically measured by weighing a 50 mm diameter sample,
T_B, temperature at the bed surface, typically measured in a pit excavated back into the crown.

TABLE I. SUMMARY OF SLAB MEASUREMENTS

Parameter	*Symbol*	*Units*	*No. of cases*	*Range* *Maximum*	*Range* *Minimum*	*Mean*	*Standard deviation*
Slope angle	θ	deg	194	55	25	38.3	4.79
Slab thickness	h	m	193	4.2	0.08	0.67	0.43
Mean density	$\bar{\rho}$	kg m^{-3}	121	461	60	206	77.2
Shear stress at bed surface	B_{xz}	N m^{-2}	121	9 050	65	964	1 049
Density at bed surface	ρ_B	kg m^{-3}	72	400	90	231	75.9
Temperature at bed surface	T_B	°C	111	0	−13	−4.58	3.08

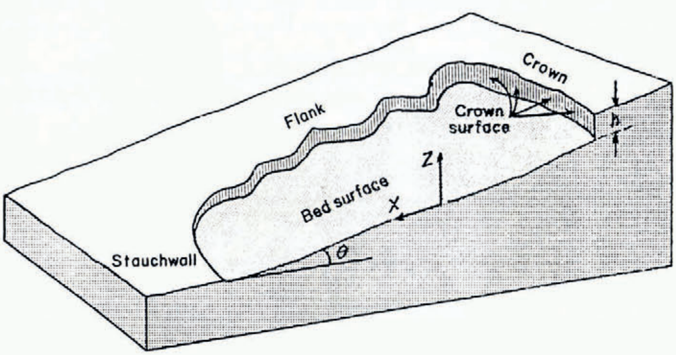

Fig. 1. Slab avalanche nomenclature and coordinate system.

The statistics of Table I are probably biased by two factors: First, the samples were taken on accessible slopes; and second, on a given sample day, the observer tended to sample the thicker slabs as opposed to smaller, more innocuous or less spectacular slabs. As a consequence of these factors, it is likely that the *sample* mean of θ is shifted to a lower value than the *population* mean, and it is almost certain that the *sample* mean of h is shifted toward a higher value. A third bias is that wet slabs were not included in proportion to their occurrence since the observations were mostly taken during winter and early spring; only 7 of the 205 observations were taken after 31 March. Thus, the *sample* mean of T_B is probably shifted to a colder value than the *population mean*. Lastly, it is possible that 50 mm density samples sometimes over-estimate ρ_B, especially when failure occurs in a thin, weak layer.

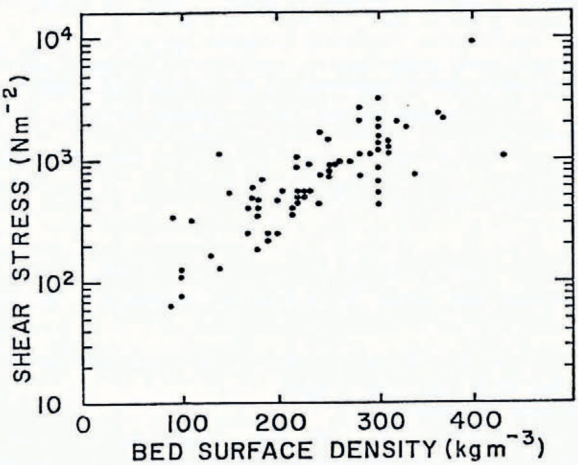

Fig. 2. Shear stress at bed surface B_{xz} versus bed surface density ρ_B, 72 cases.

Assuming that the slabs fail at stress B_{xz} it is possible to find an approximate relationship for the shear strength of bed-surface layers versus bed-surface density ρ_B. Figure 2 is a scatter plot of 72 observations of B_{xz} versus ρ_B. A power-law fit ($r = 0.81$) to the data of Figure 2 is

$$B_{xz} = 0.01\,\rho_B^{2.06}, \tag{1}$$

Equation (1) is subject to the possible bias in ρ_B. Perhaps a curve-fit based on data obtained with thin, oval density tubes would show an increase in the exponent (larger than 2.06).

Taking into account the above biases and limitations of the study, it is nevertheless possible to conclude:

Less than 1% of all slab avalanches initiate where the slope angle is less than 25°.
Less than 5% of all slab avalanches initiate where the slope angle is less than 30°.
The average shear stress at the bed surface prior to failure is in the range of 10^2 N m^{-2} to 10^4 N m^{-2}.
The most prevalent bed-surface temperature is in the band -5°C to 0°C.
Over 95% of all slab avalanches have a bed-surface temperature of -10°C or warmer.
The shear strength at the bed surface has a large variance as a function of density, but on the average varies approximately as the square of the density.

MS. received 3 November 1976 and in revised form 4 May 1977

REFERENCES

Perla, R. 1977. Slab avalanche measurements. *Canadian Geotechnical Journal*, Vol. 14, No. 2, p. 206–13.