

VARIATION OF GROUND SNOW LOADS

IN BRITISH COLUMBIA

By

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According to the National Building Code of Canada, 1965, (1) design snow-loads for roofs must be determined by multiplying a ground load with appropriate snow load factors. The ground load varies with location and the variation is particularly great in the mountains which cover most of the Province of British Columbia. The principal factors that influence the accumulation of snow on the ground are geographical location, elevation, aspect and forest cover.

Climatic regions, for the southern part of British Columbia as defined in the "British Columbia Atlas of Resources," (2) are shown on Figure 1. Major storm paths, mountain ranges, and large bodies of water influence the climate of an area, and consequently the amount of snowfall and melting of snow. Superimposed on general climatic regions are local variations of climate associated with individual mountains and valleys.

It is well known that the amount of snow on the ground usually increases with elevation. Lower air temperature, which causes more precipitation to fall as snow instead of rain, and which delays melting, is the principal reason for the increase in snow depth with elevation.

The aspect and tree cover determine whether or not the wind influences the deposition of snow and the degree to which solar radiation produces melting between snowfalls. The effects of aspect and forest cover have been summarized by Meiman (3).

Supplement No. 1 to the National Building Code 1965 (4) recommends ground loads for a number of stations. These loads were calculated from climatic records and reflect only the climatic variations at the places where weather observations were made. In mountain regions the loads are applicable mainly to locations in the valleys. Little is known how the snow loads change for locations at higher elevations. The National Research Council initiated an observation program in 1966 with the purpose of obtaining numerical values about the increase of the ground load with elevation.

Method of Observation

Observation sites were selected on a number of mountains in Southern British Columbia, preferably near centres of population where there was need for information on snow loads. A most important requirement for the selection of sites was accessibility in winter, either by road or ski tow. The locations where observations were made are shown on Figure 1.

The variables of aspect and vegetation were maintained constant and chosen so as to ensure a large snow accumulation. This was achieved by making observations in openings of large forests on mountainsides with uniform, west to north to east aspect. The openings had widths of about two tree heights. Between 6 and 12 observation sites were established on each mountain with differences in elevation of 300 ft to 400 ft between them. It was not always possible to find ideal sites and often influences of wind and sun could not be eliminated. Some sites had to be changed after the first or second winter in order to obtain the best possible conditions.

The amount of snow on the ground was measured with a Federal snow sampler; three samples were obtained at each site. Measuring a snow course of ten points at each elevation would have been more accurate, but time did not permit this number of observations. The collection of observations from as many sites as possible was considered to be more valuable than greater accuracy. Because the sites were carefully selected, the spread

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between the three samples proved to be not more than 1 in. water equivalent, which was 3 to 6 per cent of the mean. At each site only the maximum water equivalent of the snow per winter was considered for the study. The measurements were made at intervals of about two weeks at the time when the load of the snow on the ground would be expected to be maximum. The highest load was reached in January or early February in the valleys; at high elevations, (3500 ft above sea level at the coast and 6000 ft above sea level in the interior), the snow load was maximum in May.

Results

The maximum snow loads on the ground, which may be expressed in inches water-equivalent or in pounds per square foot, were plotted against elevation. An example is presented in Figure 2 for Mount Revelstoke. In this example, the observation at 3900 feet deviates significantly from the curve drawn through the points. This indicates that the observation was made at a particularly sheltered site.

The relationship between elevation and ground load can be approximated with the equation:

$$L = a H^2 + b H + c$$

where:

L = load or water equivalent at the elevation,

H, above sea level,

a, b, c = coefficients that vary with geographical location and year.

No attempt has been made to fit curves by regression analysis, because the observations were not homogeneous. The coefficients of the equation will be determined in the future when errors due to influences of aspect and vegetation have been minimized through improved selection of sites, and a large number of observations are available.

The observations of three years, 1967 to 1969, have indicated that within the same climatic region, the yearly ground load - elevation curves have a similar shape, but the origins of the curves may differ. The relation is more curved in a wet mild climate with heavy snowfalls than in a dry cold climate. Figure 3 shows observations typical for several climatic regions. The amount of precipitation is high at the coast (Seymour Mountain) and decreases eastward through the wet and dry southeast interior to the dry Rocky Mountains. The wetter the climate, the stronger is the increase of snowload with elevation. Most noteworthy are the observations from Seymour Mountain, which are almost identical with those obtained at two other stations near Vancouver. The reason for the pronounced change in the rate of increase at the 2000-ft elevation is that most storms near Vancouver deposit snow above this elevation, and produce rain at the lower elevation.

The decrease in the rate of change of snow load from West to East, or wet to dry, is also noticeable on a smaller scale as shown in Figure 4. The distance between these three locations is about 30 miles.

The general shape of the curve does not change from year to year. It remains strongly curved in wet, mild climates and close to linear in dry, cool regions. The steepness of the curve changes a little from one year to the next, and also its origin.

Similar results have been reported by others. A linear correlation of snow-water equivalent with elevation was found by Golding (5) on the eastern slope of the Rocky Mountains in Alberta and by Garstka (6) in Wyoming. Both areas have a dry climate. Anderson and West (7) reported for the Central Sierra Nevada and Packer (8) for Northern Idaho, relations that were non-linear with a greater rate of increase of snowload at high elevations. Both areas have heavy snowfalls. A second degree function between snow load and elevation was also determined for Switzerland by Zingg (9) and is specified there for the design of buildings. The climate in the Swiss mountains is similar to the climate of Southeast Interior British Columbia.

Conclusion

The relationship between elevation and ground snowload can be described by a

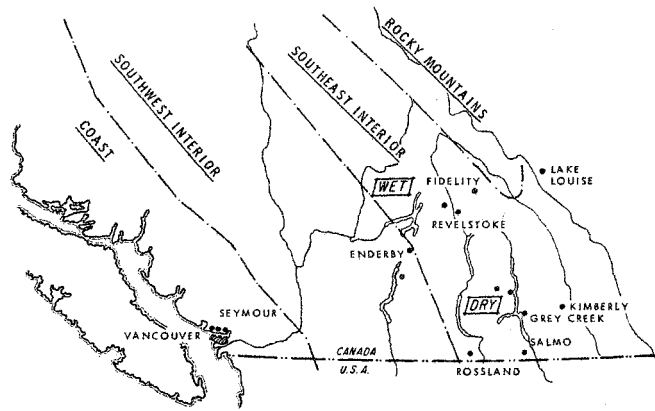


FIGURE 1
CLIMATE REGIONS AND SNOW OBSERVATION STATIONS IN SOUTHERN BRITISH COLUMBIA
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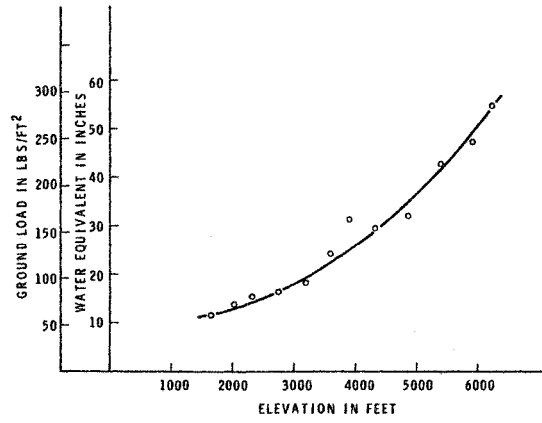


FIGURE 2 MAXIMUM SNOWLOADS MOUNT REVELSTOKE 1969
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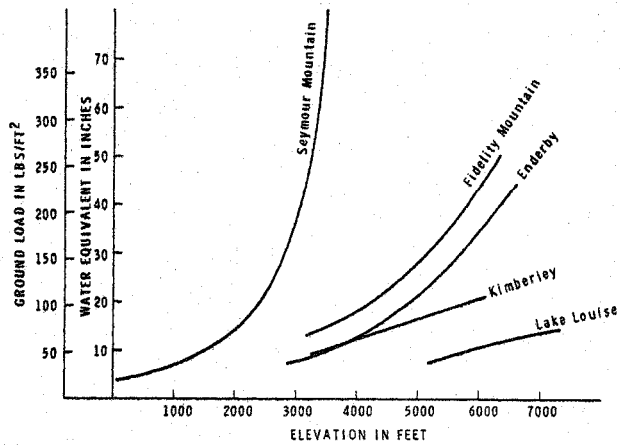


FIGURE 3 MAXIMUM SNOWLOADS IN 1969
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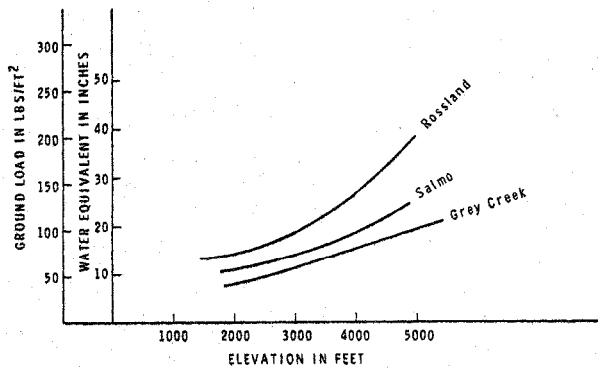


FIGURE 4 MAXIMUM SNOW LOADS IN WEST KOOTENAY 1969
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quadratic equation whose parameters depend on location and year. When observations are available for many years it should be possible to calculate maximum snowloads that could be expected to occur once in 30 years. The correlation between elevation and the 30-year maximum snowload can probably be written in the form of a second degree equation with the coefficients dependent on climate. The 30-year maximum snow loads can be expected to increase at a greater rate at high elevation in wet climate, similar to the relations established for individual years; the increase in snow load with elevation is almost linear in dry climates, such as that of the Rocky Mountains.

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