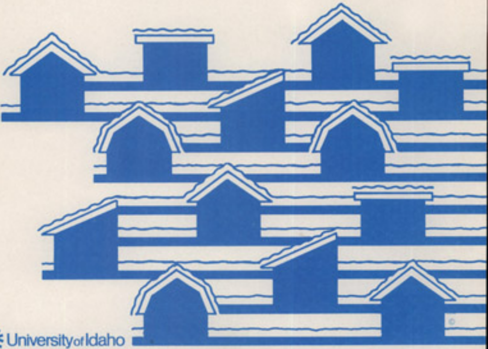
Ground and Roof Snow Loads for Idaho

R. L. Sack
A. Sheikh-Taheri



University of Idaho
Department of Civil Engineering
Moscow, Idaho 83843

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ROOF SNOW LOADS
FOR IDAHO

Ronald L. Sack

Azim Sheikh-Taheri

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PREFACE

It has been ten years since we released the first snow load study for the State of Idaho. During that time the American National Standards Institute has published their new standard on snowloads, research has pointed the way to better design recommendations, the construction industry has had an opportunity to evaluate our initial effort, and we have been working to improve and refine the snow loads for the state.

The data base for the new ground snow load map has been expanded. For this study we used ground snow loads associated with a two percent chance that the value will be exceeded in a given year (also known as a 50-year mean recurrence interval); a three percent chance was used in the 1976 study. This change was adopted to make Idaho ground snow loads consistent with those of other states. The normalized ground snow loads are shown on the accompanying color map. Color was used so that mistakes in interpretation would be minimized; the large size format was adopted so that all information could be viewed at once and still the necessary detail would be retained. The methodology for converting ground snow loads to roof loads is contained in Section 3. The information in that section is a blend taken from the American National Standards Institute and the most reliable and current research findings.

We urge our readers to use the information with care. The uncertainties associated with snow should suggest that the scatter in the data may be large in spite of our many efforts. For unusual structures or siting we suggest that all available information be considered in determining the snow loads. Finally, we remind you that the design snow loads are the ultimate responsibility of the person in charge of the project.

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Moscow, ID

GROUND AND ROOF
SNOW LOADS FOR IDAHO

By

R. L. Sack and A. Sheikh-Taheri

1.0 INTRODUCTION

Snow loading is the most severe test of roof structures in many parts of the State of Idaho. Economical structural design in these areas requires an accurate prediction of the ground snow, plus an understanding of how the snow is distributed on the roofs. A country-wide snow load map has been published by the American National Standards Institute (ANSI) (2)*. However, in certain areas, the snow loads shown are not appropriate for unusual locations such as the high country, and some territories may have extreme variations in snow deposition. As a result, building associations, local jurisdictions and entire state areas have initiated and published their own snow load studies (3, 7, 10, 13, 14, 15, 16, and 17).

The 1976 study of ground snow for Idaho (10) was the first attempt to define these loads throughout the state. This mapping used data from 270 snow course stations of the Soil Conservation Service (SCS). All of these stations were in Idaho with the exception of 28 in Montana and 7 in Wyoming. Each snow course had seven or more years of record. Maximum recorded weights of snow on the ground were selected from records taken during the seasons from 1927 to 1975. The annual maximum values of snow water equivalent for each station were analyzed for a 30-year mean recurrence interval (mri, i.e., an annual probability of 0.033 that the ground snow is exceeded) using a log Pearson type III frequency analysis. Snow depth data were used from 126 National Weather Service (NWS) stations within the state. These data were also analyzed

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*Numbers in parentheses indicate references in Section 6.0.

for a 30-year mean recurrence interval using the same log Pearson type III frequency analysis. A state-wide specific gravity was computed from the SCS data and this was used to convert the NWS depths to loads. The NWS depth data were used only if the SCS data were sparse in a particular location. The station-specific extreme values were spatially extrapolated using normalized ground snow loads (see Section 2.4). The ground-to-roof conversion factors recommended in the 1976 Idaho study were those obtained by the National Research Council of Canada and published in ANSI A58.1-1972 (1).

Various factors prompted updating the 1976 Idaho snow load study. Snow load research received a boost during the activity to update the ANSI standard, and one of the authors (Sack) was active on that snow load subcommittee. The 1982 country-wide ANSI map is based on an annual probability of being exceeded equal to 0.02 (50-year mri), and we believed that the Idaho map should use this same mri. In addition, this was an opportunity to: (a) update all annual maxima for the Idaho SCS and NWS stations; (b) include more stations from surrounding states; and (c) examine the issue of an appropriate specific gravity for the NWS snow depth data. Also, a number of studies initiated by the National Research Council of Canada (NRC) (18), the Cold Regions Research and Engineering Laboratory (CRREL) (5), and the National Science Foundation (NSF) (8, 9) have shed new light on the ground-to-roof conversion factor. The ANSI snow load subcommittee took advantage of this new information to update and improve calculation of roof snow loads. Our recommendations on ground-to-roof conversion factors incorporates what we consider to be the most accurate information on the topic.

2.0 GROUND SNOW LOADS

Prediction of extreme values for ground snow loads requires completion of a number of steps. First, all available records must be perused for annual maxima. Second, these maxima are used in conjunction with an appropriate probabilistic model to predict extreme values. These extrema for each individual station must be extrapolated spatially over the entire region. The details of the latest study for Idaho are contained in the M.S. thesis by Sheikh-Taheri (12).

2.1 Data Base

The Soil Conservation Service (SCS) and the National Weather Service (NWS) are the two principal agencies that gather data on ground snow in the United States. The NWS makes daily snow load measurements at 184 so-called first-order stations, and only daily snow depths are recorded at approximately 9,000 additional locations. The SCS makes monthly measurements of depth and water equivalent (in inches of water) for the accumulated snow. The NWS stations are typically located adjacent to towns and cities. Those of the SCS are in the remote high mountainous areas, since the information was initially intended to be used principally to predict annual runoff. The NWS stations are near the majority of the building acitivity so the construction industry could potentially make use of these data, but snow depths alone do not yield design loads. The SCS stations vastly outnumber NWS locations in Idaho.

We encounter a difference in the temporal content of the data when attempting to juxtapose SCS and NWS information. The NWS daily measurements tend to reveal small fluctuations in deposition and ablation; whereas, the monthly SCS quantities do not reflect these changes. Typically, the NWS quantities peak during January and February, and in contrast, snowpacks in the mountainous areas, as characterized by the SCS data, maximize in March and April.

A total of 514 stations from both SCS and NWS were used for this second study of Idaho. The 375 SCS stations are composed of 234 from Idaho, 93 from Montana, 30 from Oregon and 18 from Washington. All Idaho snow courses included in the study had a minimum of 10 years of record. The maximum recorded weights of snow on the ground were selected from records taken during the following snow seasons: Idaho (1927-1983); Montana (1922-1974); Oregon (1928-1972); and Washington (1915-1969). Most of the maxima for these occurred in April with a few exceptions. Snow depth data were available from 138 NWS stations in Idaho (1927-1981) plus the first-order Spokane, Washington station. The maxima for the NWS data generally occurred during January and February which reflects the usual situation where these stations are located.

2.2 Probabilistic Models

The annual maxima obtained from the data base for each station must be extrapolated beyond the historical period of observation. This is done using one of the standard cumulative probability distribution functions (cdf) as a model. The parameters describing the cdf are determined from the data at a given site. The Freshet (type II) and log-Pearson type III are both three-parameter models; whereas, the two-parameter limiting forms of these distributions are the Gumbel (type I) and lognormal, respectively. Since the cdf extrapolates extreme values from the historical data, it is imperative that the correct model be chosen by examining the data using measures such as the Chi-square test of fit, the Kologorov-Smirnov test or using probability plot correlation coefficients. For example, predicting the annual extreme water equivalents from first-order NWS sites from the Dakotas to the east coast requires both Gumbel and lognormal distributions. The Gumbel distribution is used for Canada and Europe; whereas, the ANSI study of snow loads in the United States uses the lognormal model. In the Western United States, the log Pearson type III distribution is used in California (Nevada County), Idaho, Montana, Oregon, Utah and Washington.

A value of snow load accumulation with a small probability of being exceeded in any one year is selected from the cdf for design purposes. Annual probabilities of being exceeded which range from 0.01 to 0.04 are used in the United States, but attempts are being made to standardize to the single value of 0.02. The mean recurrence interval (mri) is the reciprocal of the annual probability of being exceeded. Thus, a 50-year mri corresponds to an annual probability of being exceeded of 2 percent. It is important to note, for example, that during a 50-year period, there is a 63.6 percent chance of exceeding the value designated by the 2 percent annual probability of exceedance.

2.3 Snow Density

The snow depths recorded by the majority of the NWS stations constitute a potentially useful set of design information since these sites are typically located near populous areas. In order to use these data a number of methods have been devised to estimate the snow density. Canada initially adopted a constant specific gravity of 0.192 for all locations and added the maximum 24-hour rain occurring during the winter months. In a similar fashion, the 1976 study of the State of Idaho used a value of 0.385 which was obtained from the mean specific gravity of the 270 SCS stations within the region. This high value probably is accurate for mountainous locations where the snow compacts throughout the winter but is probably not representative for sites where the snow remains on the ground for only a short period. The assumption of constant density does not acknowledge the fact that snow deposition and density are dependent upon regional climatology. The current approach favored by Canada (4) assumes density is associated with forest type. This rationale gives mean specific gravities of 0.190 to 0.390 for the non-melt period of the year and 0.240 to 0.430 during the spring-melt interval. The methodology used by ANSI for the United States involves plotting the 50-year (mri) ground depths against the 50-year (mri) ground loads for the 184 first-order NWS stations. The resulting nonlinear regression curve relating these extreme values was used to predict ground snow loads for the NWS stations where only depths are measured. A fourth approach is reflected in the Colorado study (15); wherein snow course data from 1128 stations within the state were fit using a power law to relate snow depth and load.

For this follow-up study of Idaho we decided that all NWS snow data should be utilized; therefore, an appropriate specific gravity was chosen. A number of maps were constructed using various values, but the Rocky Mountain Conversion Density (RMCD) was judged to be most appropriate. The depth-snow load relation was obtained by fitting a bilinear distribution to data from 3,000 Western SCS stations with over five years of record. The relationships developed are graphed in Fig. 2.1, and expressed as follows:

$$\begin{aligned} & p_g = 0.90h && \text{(for } h \leqq 22 \text{ in.)} \\ \text{and} \quad & p_g = 2.36h - 31.9 && \text{(for } h \geqq 22 \text{ in.)} \end{aligned} \tag{2.1}$$

where p_g is the ground load in lb/ft^2 and h is snow depth in inches.

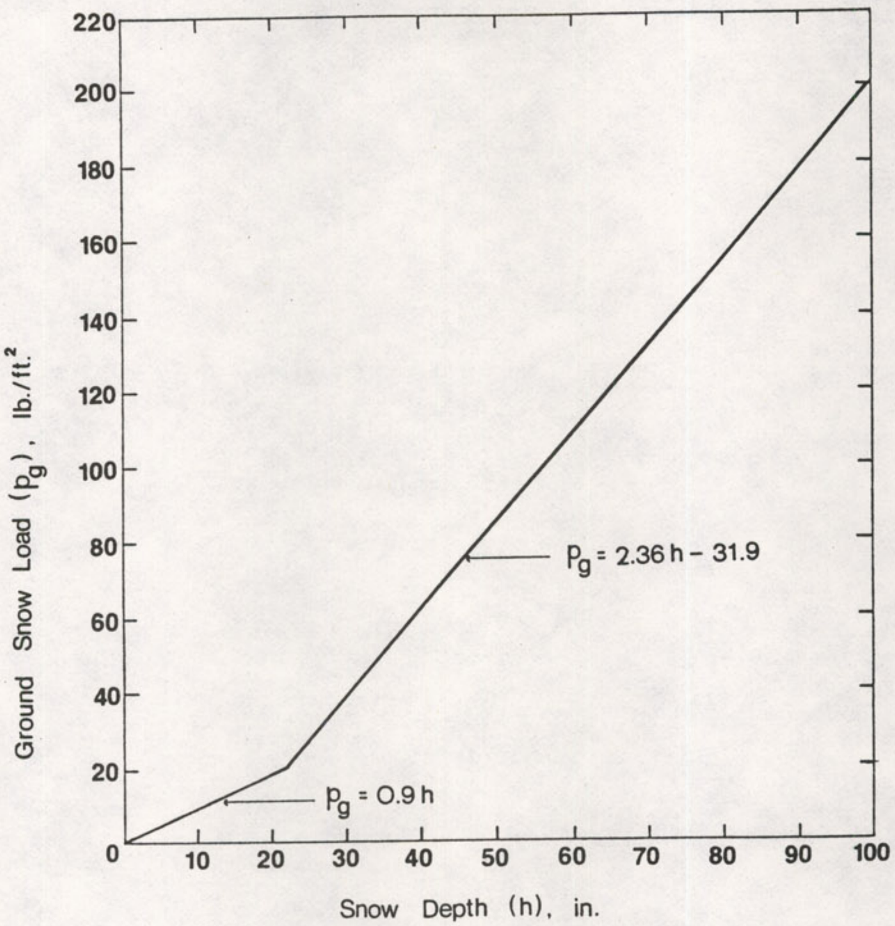


Fig. 2.1 Rocky Mountain Conversion Density
[RMCD]

For depths less than 22 in. this gives a specific gravity of 0.175 and for depths greater than 22 in. the specific gravity is variable, but if the line started from the origin it would give a value of 0.444.

2.4 Mapping

The extreme values at all stations within a region form the basis for structural design. This information can be tabulated by station but is of little value to the person required to design for a location that is not near a measurement site. It is more beneficial if snow loads for all locations within the region are extrapolated from the calculated station extreme values. Canada and the United States (ANSI) both display contour maps of ground snow loads. This method seems to work for regions with no extreme terrain features; such exceptional areas are excluded from both national studies. In the Western United States a number of methods have been developed by regional agencies to cope with this problem. The State of Oregon created curves of snow load versus elevation for each county. This makes the standard easy to administer, but there is a large amount of scatter in the data which makes single-valued relationships difficult to obtain. Another methodology is used by Arizona, California (Placer and Nevada Counties), and Colorado wherein, ground snow loads are expressed as a function of elevation. A unique relationship is derived for each of the various geographical areas within the region. Normalized ground snow load (NGSL) contours are used by Idaho, Montana, and Washington. For this technique the snow load at each measurement site (in units of force per area) is divided by the elevation of the station to give a quasi-normalized quantity in units of force divided by length cubed (i.e., pounds per square foot per foot of elevation, - psf/ft). These quantities seem to have no obvious physical significance, but the process in effect reduces the entire area to a common base elevation. This procedure masks out the effect of the environment on the snow-making mechanism and gives single-valued contours that are impossible to obtain without normalization.

We elected to use normalized ground snow loads following the approach established for the state in the 1976 study. The computer plotting program SURFACE II (11) was used to generate contour maps of normalized ground snow loads. The surface of snow loads is approximated by superimposing a regular rectangular grid of values over the region and interpolating between these points. Typically mesh point values are determined by a two-part procedure. First, the slope of the surface is estimated at every data point, and second the value of the surface at the grid nodes is estimated using a weighted average of the nearest neighboring data points. The user can select from a number of different weighting functions. The grid size must also be specified by the user. Using all 375 SCS data points and the 139 NWS snow depths converted to loads, we created two maps each with a grid size of 100,000 ft. The scale of the map is 1:1,000,000 (i.e., 1 in. = 83,333 ft). These maps used weighting functions of $1/D^2$ and $1/D^6$, where D is the distance from the grid point to the snow measurement station. The first weighting function is appropriate for relatively flat regions, while the second characterizes behavior in mountainous areas. Since SURFACE II does not allow specifying different weighting functions for different locations on the same map, we decided to overlay the two computer-generated maps to produce one which represented the input data as accurately as possible. During this procedure, a topographic map of Idaho was also overlaid to assist in determining the location of the valleys and mountains. Thus by making a composite of these two maps we produced the final snow load map for the State of Idaho with an annual probability of 0.02 that the ground snow load is exceeded.

2.5 Anomalies

Some exceptions to the contour lines were noted during the mapping process. Ground snow loads for cities and towns were calculated from each map produced, and these loads were compared to the input data to check the accuracy of the mapping. We checked the areas which were not represented accurately by the contours and studied these in more detail. One such area is Coeur d'Alene where the RMCD proved to be inadequate for predicting snow loads from the snow depths of the NWS. Therefore, we obtained a conversion factor to convert the maximum depth to the maximum load at this station. The maximum annual water equivalents were selected from the Spokane first-order NWS station for the past 28 years and the 50-year (mri) value was calculated. Similarly, maximum annual snow depths were analyzed and the 50-year (mri) snow depth was obtained.

Both extreme values were computed using the log Pearson type III frequency analysis. A conversion factor of 0.233 was calculated for Spokane by dividing the extreme value of water equivalent by the extreme value of depth. This value was applied to the NWS depth at the Coeur d'Alene station. Boise, Lewiston and Pocatello are also all first-order NWS stations where snow water equivalents are recorded; therefore, at these locations these data were used and the NWS depths disregarded.

Another type of exception was noted for locations where the normalized ground snow load was known and could not be represented by a contour line. One of these exceptions occurred at Riggins (a NWS station) and another at Bear Mountain (a SCS station). The normalized snow load value for Riggins is 0.005, and the contour lines around this town were between 0.025 and 0.030. Similarly, the value of normalized ground snow load for Bear Mountain is 0.120, and the contours around it have a value of 0.055. Since the contour interval is 0.005, this difference in values can not be shown without adding more contours which cannot be justified. Therefore, the value of the normalized ground snow load for such locations were noted as exceptions, and these are represented on the map by a + sign accompanied by the NGSL value.

2.6 Using The Map

The map of ground snow loads represents the most current and accurate information available. More than three-man years of intensive effort has been invested over the past two years, and the study has been ongoing since the 1976 study was completed. Each of the 514 stations required a search through the historical records to obtain annual maxima, followed by calculation of the extreme value for the individual stations. We have generated approximately 150 individual maps to study all locations and effects in detail. The effort has been enormous and without funding; therefore, we respectfully request that the copyright of the map be respected.

The map was done in color to avoid ambiguities. For example, if a circular contour is encountered: what is the value inside the contour? One can guess that if all contours leading to this final circle are increasing in value then this must be a "peak" and the snow loads inside assumed to be larger than the value on the contour line. Color coding eliminates the need to do this guessing. Note that the colors denote a range of values between contour lines; therefore, linear interpolation is recommended between contour lines to obtain the most accurate value. Contiguous zones of the same color can exist. For example, in the south east corner of the state two light green zones (0.010-0.05) occur side by side. Physical interpretation reveals a zone of high values on the north decreasing to a "valley" of 0.010 and the values increasing again to the south. With linear interpolation no amomalies occur. Ground snow loads for cities and towns within Idaho are tabulated in Appendix A.

The snow loads presented on the map represent those for the 50-year mean recurrence interval (i.e., there is 2 percent chance that the value will be exceeded in a given year). The 1976 study was based upon a 30-year mri. Also, there are approximately eight more years of record for each station in the current study. Therefore, it is logical to anticipate that the ground snow loads from the two studies will differ. For high elevation locations, ground snow loads prescribed by the current study are generally higher than those obtained in the 1976 study. This is to be expected because the SCS records dominate in these regions, and the value associated with a 50-year mri is inevitably larger than that of a 30-year mri (as used in the 1976 study). Also, for some lower elevation areas such as valleys and plains, the ground snow loads are lower than those from the 1976 report. This results from applying lower specific gravities to the snow depths measured in these locations. Recall that in the 1976 report a specific gravity of 0.385 was applied to all NWS stations; whereas for this study the specific gravity is a function of snow depth.

For most permanent structures and buildings, the 50-year mri ground snow load should be used, but the user of this map may wish to obtain snow loads associated with mri's other than the 50-year value. We calculated that $\bar{X}_{25}/\bar{X}_{50}$, $\bar{X}_{30}/\bar{X}_{50}$, and $\bar{X}_{100}/\bar{X}_{50}$ are 0.952, 0.967, and 1.042, respectively for the Idaho SCS water equivalents, and 0.884, 0.911, and 1.116, respectively for the NWS depths ($\bar{X}_N$ is the mean value with a N-year mri). The change of map values for various mri's is incorporated in the importance factor, I, as shown in Table 3.2. Using averages for all first-order NWS stations in the U.S. ANSI found the ratio of the mean values for the 25-year mri and 50-year mri averaged 0.81, while the ratio of the 100-year mri and 50-year mri averaged 1.21. These values were used to obtain the importance factors presented in ANSI A58.1-1982 (2). For Idaho we have used all ANSI values for I, with the exception of that for low-hazard structures for which we recommend a value of 0.90 to reflect the Western snow behavior (see Table 3.2).

As a final precaution, we point out that local anomalies due to unique microclimates, unusual terrain, etc. should be studied where additional data are available. <u>The final design snow loads are the ultimate responsibility of the engineer, architect, local building official, and/or contractor in charge of the project.</u>

3.0 ROOF SNOW LOADS

The procedure described in this section for determining design snow loads is based upon the ANSI recommendations (2), and these have been augmented with the latest information on the thermal and slope coefficients, plus drifting criteria ((8), (9), and (6), respectively). For unusual situations, refer to current applicable research results or ANSI A58.1-1982 (2).

Ground snow loads, p_g, to be used in determining design snow loads for roofs are given on the accompanying map of the State of Idaho. For areas where local records and/or experience indicate that the ground snow load, as determined by the map, are inadequate, design loads should be specified or approved by the local building official or other responsible authority.

3.1 Basic Design Snow Loads

The snow load, p_f, on an unobstructed flat roof (i.e., any roof with a slope less than 1 in./ft,--5°) shall be calculated as follows:

$$p_f = 0.7C_eC_tIp_g \tag{3.1}$$

where: p_f = flat-roof snow load in pounds-force per square foot; C_e = exposure factor (see Table 3.1); C_t = thermal factor (see Fig. 3.1); I = importance factor (see Table 3.2); and p_g = ground snow load in pounds-force per square foot.

The relationships shown in Fig. 3.1 for C_t are expressed in the following formulas:

Category T1--roof heated;

$$C_t = \begin{cases} 0.80 & (R \leq 10) \\ 0.60 + 0.02R & (10 \leq R \leq 40) \\ 1.40 & (R \geq 40) \end{cases} \qquad (3.2)$$

Category T2--roof kept just above freezing;

$$C_t = \begin{cases} 1.00 + 0.01R & (0 \leq R \leq 40) \\ 1.40 & (R \geq 40) \end{cases} \qquad (3.3)$$

Category T3--roof unheated;

$$C_t = 1.60 \qquad (\text{all } R) \qquad (3.4)$$

where R is the thermal resistivity of the roof in °F hr ft^2/BTU.

If p_g is 20 lb/ft^2 or less, p_f must be at least Ip_g and if p_g exceeds 20 lb/ft^2, p_f must be at least $20I(lb/ft^2)$, i.e.,

$$p_f \geq Ip_g \qquad (\text{if } p_g \leq 20 \text{ lb/ft}^2) \qquad (3.5)$$

$$p_f \geq 20I \qquad (\text{if } p_g > 20 \text{ lb/ft}^2) \qquad (3.6)$$

3.2 Snow Loads on Sloped Roofs

All snow loads acting on a sloping surface shall be considered to act on the horizontal projection of that surface. The sloped-roof snow load, p_s, shall be obtained by multiplying the flat-roof snow load, p_f, by the roof slope factor, C_s, i.e.,

$$p_s = C_s p_f \qquad (3.7)$$

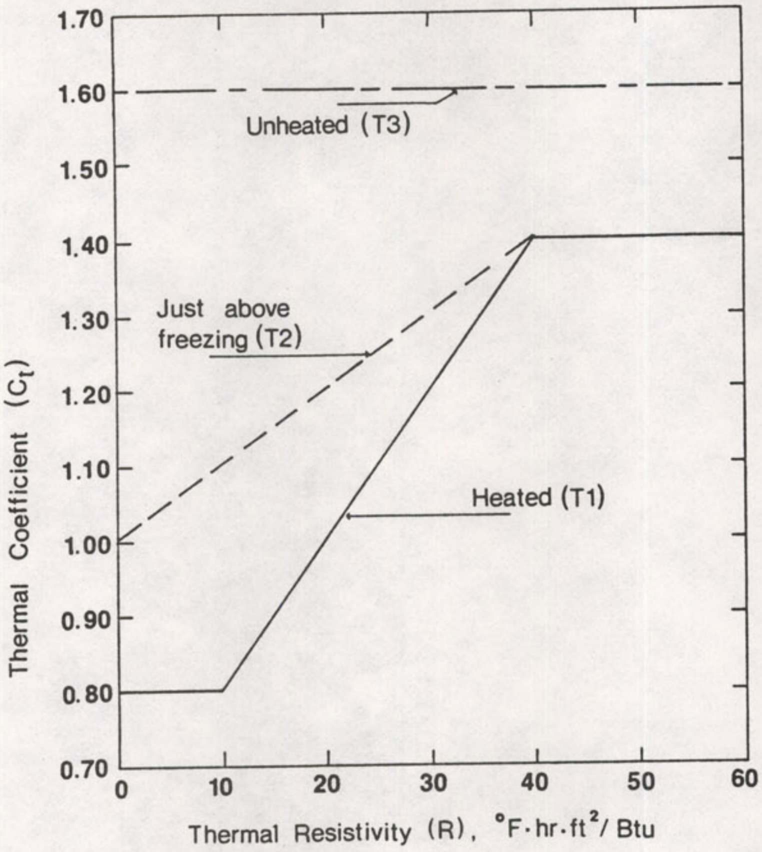
The flat-roof snow load may be reduced in accordance with Eq. (3.7) provided that the eave height of all roofs (including dormers) is equal

Table 3.1
Exposure Factor, C_e

Nature of Site

A	Windy area with roof exposed on all sides with no shelter* afforded by terrain, higher structures, or trees	0.8
B	Windy areas with little shelter* available	0.9
C	Locations in which snow removal by wind cannot be relied on to reduce roof loads because of terrain, higher structures, or several trees nearby	1.0
D	Areas that do not experience much wind and where terrain, higher structures, or several trees shelter the roof*	1.1
E	Densely forested areas that experience little wind, with roof located tight in among conifers	1.2

* Obstructions within a distance of $10h_o$ provide "shelter," where h_o is the height of the obstruction above the roof level. If the obstruction is created by deciduous trees, which are leafless in winter, C_e may be reduced by 0.1



Notes:

1. $C_t = 1.60$ for approved double (cold) roofs.
2. The heating and R value should be representative of those that are likely to exist during the life of the structure.

Fig. 3.1 Thermal Coefficient as a function of roof R value.

Table 3.2
Importance Factor, I[*]

Nature of Occupancy

All buildings and structures except those listed below.....1.0

Buildings and structures where the primary occupancy is one in which more than 300 people congregate in one area...1.1

Buildings and structures designated as essential facilities;...1.2
including, but not limited to:
  (1) hospital and other medical facilities having surgery or emergency treatment areas;
  (2) fire or rescue and police stations;
  (3) primary communication facilities and disaster operation centers;
  (4) power stations and other utilities required in an emergency;
  (5) structures having critical national defense capabilities.

Buildings and structures that represent a low hazard to human life in the event of failure, such as agricultural buildings, certain temporary facilities, and minor storage facilities...0.9

[*] Used to change the ground snow loads from a 50-year mri.

to or greater than the maximum anticipated snow depth. In addition, no obstructions shall occur for a distance from the structure equal to the maximum anticipated snow depth.

3.2.1 Warm-Roof Slope Factor--For warm roofs (i.e., heated roofs in category T1 with R<40 and roofs kept just above freezing in category T2 with R<40) the values of C_s are shown in Fig. 3.2a and given as follows:

Unobstructed slippery surfaces;

$$C_s = \begin{cases} 1.0 - \alpha/70 & (0^\circ \leqq \alpha \leqq 70^\circ) \\ 0.0 & (\alpha \geqq 70^\circ) \end{cases} \tag{3.8}$$

All other surfaces;

$$C_s = \begin{cases} 1.0 & (0^\circ \leqq \alpha \leqq 30^\circ) \\ 1.0 - (\alpha-30)/40 & (30^\circ \leqq \alpha \leqq 70^\circ) \\ 0.0 & (\alpha \geqq 70^\circ) \end{cases} \tag{3.9}$$

where α is the slope of the roof in degrees.

3.2.2 Cold Roof Slope Factor--For cold roofs (i.e., unheated roofs in category T3, other roofs with R≧40, and/or approved double roofs) the values of C_s are shown in Fig. 3.2b and given as follows:

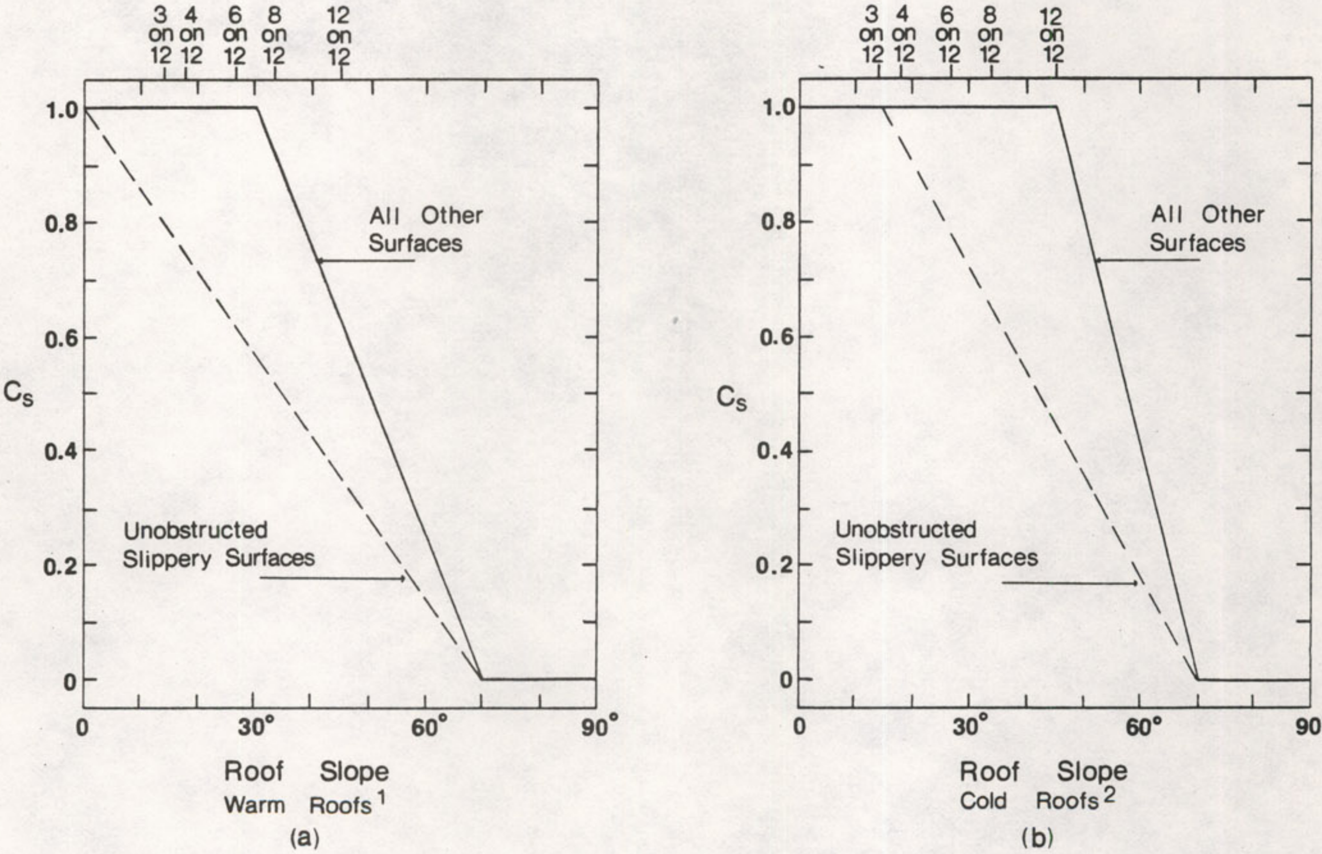
Unobstructed slippery surfaces;

$$C_s = \begin{cases} 1.0 & (0^\circ \leqq \alpha \leqq 15^\circ) \\ 1.0 - (\alpha-15)/55 & (15^\circ \leqq \alpha \leqq 70^\circ) \\ 0.0 & (\alpha \geqq 70^\circ) \end{cases} \tag{3.10}$$

All other surfaces;

$$C_s = \begin{cases} 1.0 & (0^\circ \leqq \alpha \leqq 45^\circ) \\ 1.0 - (\alpha-45)/25 & (45^\circ \leqq \alpha \leqq 70^\circ) \\ 0.0 & (\alpha \geqq 70^\circ) \end{cases} \tag{3.11}$$

3.2.3 Roof Slope Factor for Curved Roofs--Portions of curved roofs having a slope exceeding 70° shall be considered free from snow load. The point at which the slope exceeds 70° shall be considered the "eave" for such roofs. For curved roofs, the roof slope factor, C_s, shall be determined from the appropriate curve in Fig. 3.2 (or from Eqs.



(a)

(b)

[1] Heated roofs (T1) with R<40, and roofs kept just above freezing (T2) with R<40.

[2] All unheated roofs (T3), other roofs with R≥40, and approved double (cold) roofs.

Fig. 3.2 Roof slope factor, C_s, for warm and cold roofs

(3.8)-(3.11)) by basing the slope on the vertical angle from the "eave" to the crown.

3.2.4 Roof Slope Factor for Multiple Folded Plate, Sawtooth, and Barrel Vault Roofs--No reduction in snow load shall be applied because of slope.

3.3 Unloaded Portions

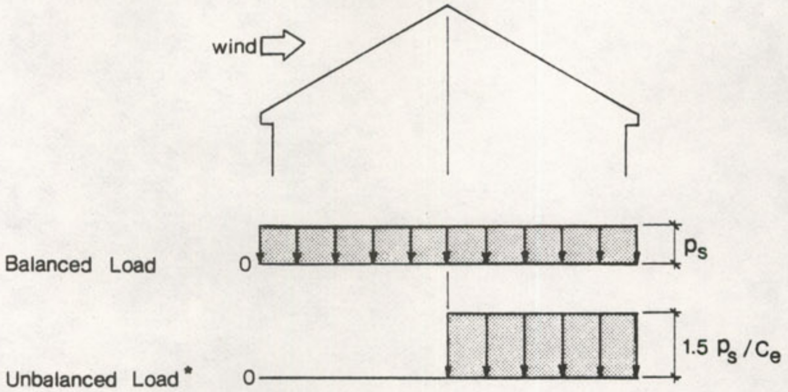
The effect of removing half the balanced snow load (i.e., $0.5p_s$) from any portion of the loaded area shall be considered.

3.4 Unbalanced Roof Snow Loads

Winds from all directions shall be considered when establishing unbalanced loads.

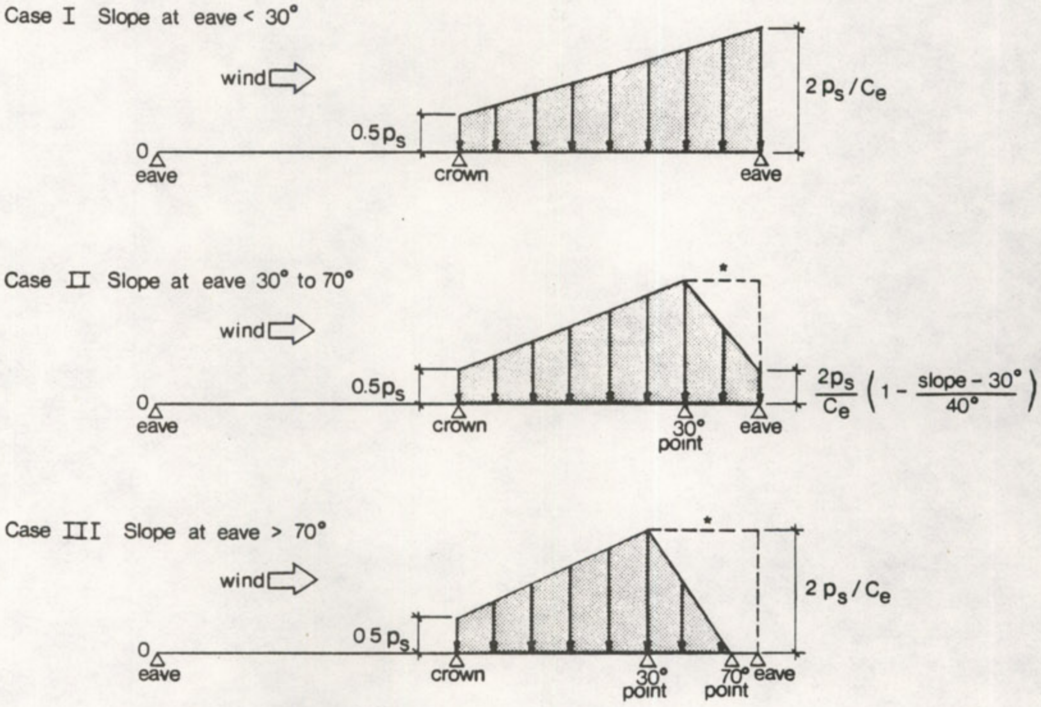
3.4.1 Unbalanced Snow Load for Hip and Gable Roofs--For hip and gable roofs with a slope less than 15° or more than 70°, unbalanced snow loads need not be considered. For roofs with slopes between 15° and 70°, a separate load calculation will be made with the lee side sustaining an unbalanced uniform load equal to $1.5p_s/C_e$. In the unbalanced situation, the windward side shall be considered free of snow. See Fig. 3.3 for balanced and unbalanced loading diagrams.

3.4.2 Unbalanced Snow Load for Curved Roofs--Portions of curved roofs having a slope exceeding 70° shall be considered free of snow load. The equivalent slope of a curved roof for use in Fig. 3.2 is equal to the slope of a line from the eave or the point at which the slope exceeds 70° to the crown. If the equivalent slope is less than 10° or greater than 60°, unbalanced snow loads need not be considered. Unbalanced loads shall be determined using the loading diagrams in Fig. 3.4. In all cases the windward side shall be considered free of snow. If the ground or another roof abuts a Case-II or Case-III arched roof structure (refer to Fig. 3.4) at or within 3 ft of its eave, the snow load shall not be decreased between the 30° point and the eave but shall remain constant at $2p_s/C_e$. This alternative distribution is shown as a dashed line in Fig. 3.4.



*If slope is < 15° or > 70° unbalanced loads need not be considered

Fig. 3.3 Balanced and unbalanced snow loads for hip and gable roofs [After ANSI 2]


Case I Slope at eave < 30°

Case II Slope at eave 30° to 70°

Case III Slope at eave > 70°

*Alternate distribution if another roof abuts

Fig. 3.4 Unbalanced loading conditions for curved roofs [After ANSI 2]

3.4.3 Unbalanced Snow Load for Multiple Folded Plate, Sawtooth, and Barrel Vault Roofs--According to Section 3.2.4, $C_s = 1.0$ for such roofs, and the balanced snow load equals p_f. The unbalanced snow load shall increase from one-half the balanced load at the ridge or crown to three times the balanced load given in Section 3.2.4 divided by C_e at the valley (see Fig. 3.5). However, the snow surface above the valley shall not be at an elevation higher than that above the ridge (use the RMCD from Eq. (2.1) in computing the depth). This may limit the unbalanced load to somewhat less than $3p_f/C_e$.

3.5 Drifts on Lower Roofs and Adjacent Structures

Roofs shall be designed to sustain localized loads from snow drifts that can be expected to accumulate on them in the wind shadow of: higher portions of the same structure; and adjacent structures and terrain features.

The geometry of the surcharge load due to snow drifting shall be approximated by a triangle as shown in Fig. 3.6. This triangular loading shall be superimposed on the balanced roof snow load, p_s. If $(h_r-h_b)/h_b$ is less than 0.20, drift loads need not be considered. The maximum height of the drift, h_d, in ft shall not exceed (h_r-h_b) and is computed as follows:

$$h_d = 0.43\sqrt[3]{L_u}\ \sqrt[4]{p_g+10}\ -1.5 \qquad (3.12)$$

Where L_u, the length of the upper roof, shall be not less than 25 ft nor greater than 600 ft. The density of the drift in lb/ft^3 is computed as follows:

$$\gamma_d = (0.13p_g + 14) \leqq 35\ lb/ft^3 \qquad (3.13)$$

The extra snow load at the top of the drift, p_d, equals $h_d\gamma_d$ (the graph of p_d versus p_g is shown in Fig. 3.7), and the total load there equals p_d plus p_s. The drift surcharge load shall diminish to zero at a distance of $4h_d$ from the change in roof elevation.

The drift load on a lower roof within 20 ft of a higher structure shall be determined by the method described above, except that the maximum intensity of the drift load, p_d, shall be reduced by the factor

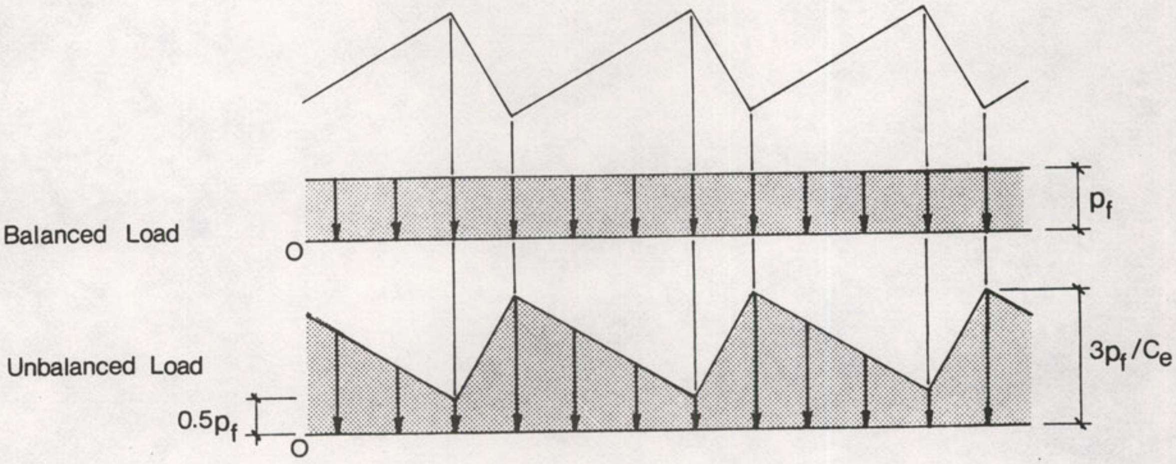


Fig. 3.5 Balanced and unbalanced loads for a sawtooth roof [After ANSI 2]

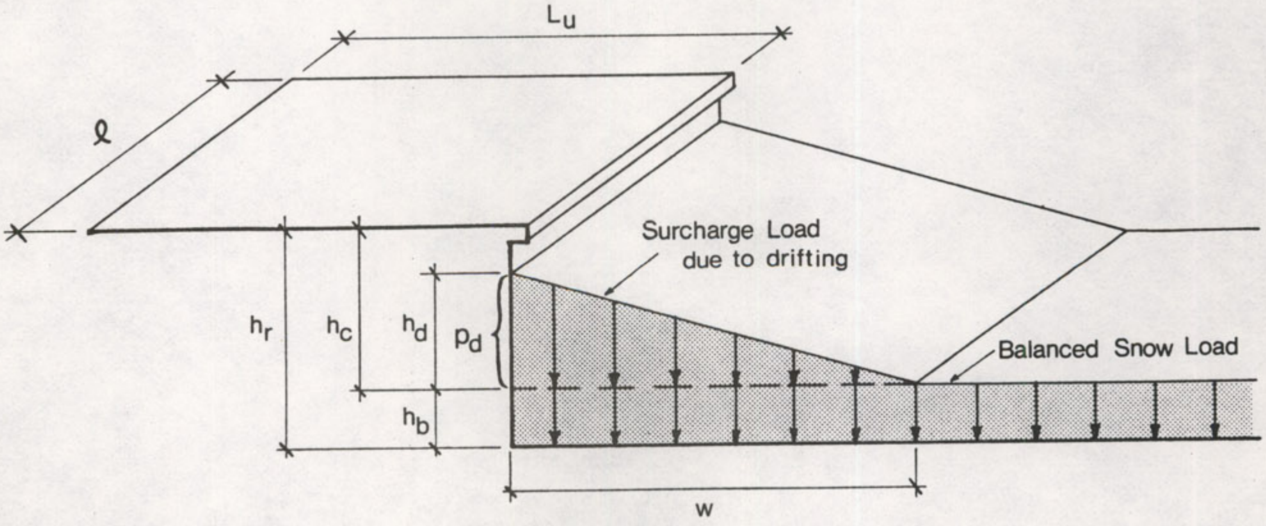


Fig. 3.6 Configuration of drift on lower roofs

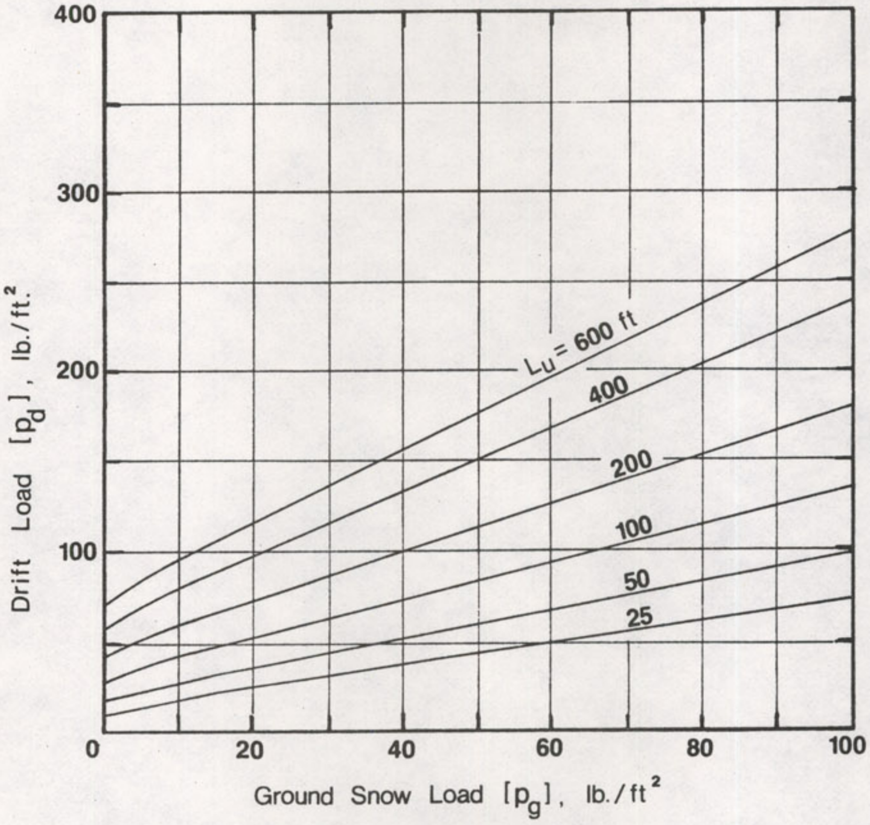


Fig. 3.7 Drift Load, $p_d = h_d \gamma_d$ - Eqs. (3.12) and (3.13)

(20-s)/20 to account for the horizontal separation (s) between the buildings.

3.6 Roof Projections

The method in Section 3.5 shall be used to calculate drift loads on all sides of roof obstructions that are longer than 15 ft. The height of the obstruction shall be set equal to h_r. The drift behind a parapet wall shall be computed using half the drift height given by Eq. (3.12), (i.e., $0.5h_d$), using Lu as the length of the roof. The density is computed from Eq. (3.13).

3.7 Snow Sliding Onto Lower Roofs

If the roof from which the snow slides has an unobstructed slippery surface with a slope exceeding 10°, sliding can be expected. For roofs with other unobstructed surfaces, sliding can be expected if its slope exceeds 20°. Where snow can slide off roofs onto lower roofs, sliding loads shall be determined assuming that half the balanced snow load on the upper roof (i.e., $0.5p_s$) slides onto the lower roof. Where a portion of the sliding snow cannot slide onto the lower roof because it is blocked by snow already there or where a portion of the sliding snow is expected to slide clear of the lower roof, the sliding snow load on the lower roof may be reduced accordingly.

3.8 Rain On Snow

In areas where intense rains may add to the roof snow load, the jurisdictional authority may require the use of a rain-on-snow surcharge load of 5 lb/ft^2 for roofs with a slope of 0.5 in. per foot or less. This surcharge is not needed in areas where p_g exceeds 50 lb/ft^2.

3.9 Water Accumulation

All roofs shall be designed with sufficient slope or camber to assure adequate drainage when subjected to design snow loads and after the long-time deflection from dead load. Alternatively, they shall be designed to support the ponding loads that could occur under these conditions. Each portion of a roof shall be designed to sustain the load of all rainwater that could accumulate on it if the primary drainage system for that portion is blocked by snow, ice or debris. If the overflow drainage provisions contain drain lines, such lines shall be independent of any primary drain lines.

4.0 SPECIAL DESIGN CONSIDERATIONS

4.1 Ice Damming

All building exits shall be protected from sliding or impact of snow and ice. For locations where p_g is greater than 70 lb/ft^2, all unheated overhangs shall be designed for a load of $2p_s$ to account for ice dams and accumulation of snow. Heat strips or other exposed heat methods may not be used in lieu of this design. Where p_g is equal to or greater than 70 lb/ft^2, hot or cold mop underlayment roofing is required on all roofs from the building edge for 5 ft or to the ridge, whichever is less. When approved by the jurisdictional authority, the underlayment may be omitted based upon data submitted which clearly shows ice damming will not occur. When approved by the jurisdictional authority, a double, or so-called "cold roof," may be used as an alternative to designing for the ice on overhangs.

4.2 Lateral Snow Pressure

Where P_g is greater than 70 lb/ft^2 all roof projections (e.g., gas, oil and solid fuel vents and chimneys) for roofs of 15° or more (except those within 36 in. of the ridge) shall be protected with ice splitters or crickets. All ice splitters shall be constructed the full width of the projection at its base. Two-thirds of the projected area which is below the maximum anticipated snow depth shall be protected. Ice splitters shall be designed for appropriate base shear and bending moment.

Where p_g is 70 lb/ft^2 or greater, structures within a distance equal to maximum anticipated snow depth to embankments or similar obstructions shall have walls designed for sliding roof snow being forced against the walls. Also in areas where p_g is 70 lb/ft^2 or greater and the structure can be subjected to the creep and glide action of the snowpack, proper lateral anchoreage and support must be provided for the building.

4.3 Roof Maintenance

Maintenance loads occur primarily as the result of the snow removal process. Snow removal can be done in a systematic manner so that no overloading of the structure occurs, and the structure will only be loaded temporarily with very small snow loads. This approach is suggested in several areas. If however, the structure is designed to take advantage of the reduced loads resulting from shoveling, it could be a problem if the snow were not removed. In general we recommend that no reduction be allowed for snow removal because: (a) removal in general is not always done; (b) removal from the center of large roofs can not be effectively done; and (c) unbalanced loading can occur during removal.

5.0 SYMBOLS AND NOTATION

C_e = exposure factor (see Table 3.1)
C_s = slope factor (see Fig. 3.2)
C_t = thermal factor (see Fig. 3.3)
D = distance from map grid point to snow station
h = ground snow depth, in in.
h_b = height of balanced snow load (i.e., balanced snow load, p_f or p_s divided by the density obtained from Eq. (3.13), in ft
h_c = clear height from top of balanced snow load on lower roof to closest point on adjacent upper roof, in ft
h_d = height of snow drift, in ft
h_o = height of obstruction above roof level, in ft
h_r = difference in elevation between upper and lower roofs, in ft
I = importance factor used to change ground snow loads from 50-year mri to others (see Table 3.2)
L_u = length of upper roof upwind of drift (see Fig. 3.6), in ft
p_d = maximum intensity of drift surcharge load, in lb/ft^2
p_f = flat-roof snow load, in lb/ft^2
p_g = ground snow load (see accompanying map), in lb/ft^2
p_s = sloped-roof snow load, in lb/ft^2
R = thermal roof resistivity, in $°F \cdot hr \cdot ft^2/BTU$
$\bar{X}_N$ = a mean value with a N-year mri

w = width of snow drift, in ft

α = roof slope, in degrees

γ_d = snow drift density (see Eq. (3.13)), in lb/ft^3

6.0 REFERENCES

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APPENDIX A TABULATION OF IDAHO GROUND SNOW LOADS*

COUNTY City or Town	ELEVATION (ft)	GROUND SNOW Loads (lb/ft^2)
ADA		
Boise	2740	14
Eagle	2555	13
Garden City	2660	13
Kuna	2960	15
Meridian	2605	13
ADAMS		
Council	2913	87
New Meadows	3868	97
BANNOCK		
Arimo	4736	95
Chubbuck	4470	37
Downey	4855	70
Inkom	4525	91
Lava Hot Springs	5000	93
McCammon	4750	95
Pocatello	4460	45
BEAR LAKE		
Bloomington	5969	90
Georgetown	6006	102
Montpelier	5945	59
Paris	5966	90
St. Charles	5985	90
BENEWAH		
Chatcolet	2136	66
Plummer	2557	51
St. Maries	2216	82
Tensed	2550	38
BINGHAM		
Aberdeen	4404	22
Basalt	4585	55
Blackfoot	4504	23
Firth	4555	46
Shelley	4625	49
BLAINE		
Bellevue	5190	88
Haily	5330	107
Kethchum	5890	118
Sun Valley	5920	118

*Computed using values of normalized ground snow loads from the accompanying state map.

BOISE		
Crouch	3021	70
Horseshoe Bend	2604	51
Idaho City	3906	117
Placerville	4320	108
BONNER		
Clark Fork	2085	115
Hope	2063	113
Kootenai	2120	111
Old Town	2160	76
Ponderay	2120	108
Priest River	2080	73
Sandpoint	2085	104
BONNEVILLE		
Ammon	4714	50
Idaho Falls	4710	47
Iona	4875	49
Irwin	5326	76
Swan Valley	5277	73
Ucon	4808	43
BOUNDARY		
Bonners Ferry	1787	89
Moyie Springs	2204	110
BUTTE		
Arco	5328	75
CAMAS		
Fairfield	5056	101
CANYON		
Caldwell	2365	12
Melba	2659	13
Middleton	2400	12
Nampa	2480	12
Notus	2315	12
Parma	2225	11
Wilder	2424	12
CARIBOU		
Bancroft	5423	81
Grace	5533	77
Soda Springs	5773	87
CASSIA		
Albion	4750	24
Burley	4165	21
Delco	4201	21
Malta	4540	23
Oakley	4584	23

CLARK		
Dubois	5150	52
Spencer	5883	88
CLEARWATER		
Elk River	2918	143
Orofino	1027	23
Pierce	3087	108
Weippe	3029	91
CUSTER		
Clayton	5471	82
Challis	5283	26
Lost River	6167	93
Mackay	5900	75
Stanley	6260	94
ELMORE		
Mountain Home	3140	16
Glenns Ferry	2555	20
FRANKLIN		
Clifton	4849	53
Dayton	4818	48
Franklin	4504	56
Oxford	4798	58
Preston	4720	47
Weston	4605	51
FREMONT		
Ashton	5260	85
Drummond	5607	92
Island Park	6280	171
Newdale	5069	51
Parker	4924	44
St. Anthony	4970	50
Teton	4949	45
Warm River	5302	106
GEM		
Emmette	2397	20
GOODING		
Bliss	3262	24
Gooding	3570	29
Hagerman	2959	18
Wendell	3467	17

IDAHO		
Cottonwood	3410	55
Ferdinand	3728	65
Grangeville	3390	34
Kooskia	1260	25
Riggins	1800	9
Stites	1245	25
Whitebird	1560	26
JEFFERSON		
Hamer	4814	29
Lewisville	4795	37
Menan	4795	37
Mud Lake	4785	24
Rigby	4855	41
Ririe	4960	50
Roberts	4755	32
JEROME		
Eden	3950	20
Hazelton	4063	20
Jerome	3781	19
KOOTENAI		
Athol	2391	68
Coeur d' Alene	2187	60
Dalton Gardens	2440	67
Harrison	2125	64
Hauser	2130	55
Hayden	2283	63
Post Falls	2172	56
Rathdrum	2196	58
Spirit Lake	2567	72
State Line	2120	53
Worley	2654	62
LATAH		
Bovill	2874	137
Deary	2960	111
Genesee	2675	54
Juliaetta	1085	24
Kendrick	1220	31
Moscow	2575	64
Potlatch	2519	50
Troy	2460	70
LEMHI		
Leadore	5989	60
Patterson	6000	60
Salmon	4004	20

LEWIS		
Craigmont	3727	61
Kamiah	1195	24
Nezperce	3150	32
Reubens	3498	56
Winchester	4000	80
LINCOLN		
Dietrich	4065	29
Richfield	4306	39
Shoshone	3970	32
MADISON		
Rexburg	4856	40
Sugar	4894	42
MINIDOKA		
Acequia	4165	21
Heyburn	4150	21
Minidoka	4280	21
Paul	4145	21
Rupert	4158	21
NEZ PERCE		
Culdesac	1689	22
Lapwai	964	12
Lewiston	739	7
Peck	1080	24
ONEIDA		
Malad City	4700	47
OWYHEE		
Homedale	2237	11
Marsing	2249	11
Grand View	2365	21
PAYETTE		
Fruitland	2226	18
New Plymouth	2255	17
Payette	1250	19
POWER		
American Falls	4404	22
Rockland	4660	42
SHOSHONE		
Kellogg	2308	58
Mullan	3277	164
Osburn	2530	118
Pinehurst	2240	90
Smelterville	2219	91
Wallace	2744	137
Wardner	2637	113

TETON		
Driggs	6116	61
Tetonia	6050	97
Victor	6207	99
TWIN FALLS		
Buhl	3793	19
Castleford	3866	19
Filer	3965	20
Hansen	4012	20
Hollister	4515	23
Kimberly	3930	20
Murtaugh	4082	20
Twin Falls	3745	19
VALLEY		
Cascade	4790	110
Donnelly	4875	195
McCall	5030	151
WASHINGTON		
Cambridge	2651	83
Midvale	2552	70
Weiser	2115	32
SKI AREAS		
Bogus Basin Lodge	6200	93
Brundage Mtn. Lodge	6040	194
Schweitzer Basin Lodge	4700	235
Silverhorn Lodge	5040	217
Sun Valley Mt. Baldy	9000	188

APPENDIX B DESIGN EXAMPLES

Example B.1: A shed roof structure is located at an elevation of 3730 ft near Craigmont in Lewis County where NGSL = 0.0165 psf/ft. Tall coniferous trees, 300 ft away, surround the structure. It is an unheated storage building with R = 5, and has an unobstructed slippery metal roof with a slope of 40°.

Ground snow load (Eq. (3.1)):

$$p_g = 0.0165(3730) = 62 \text{ lb/ft}^2$$

Flat-roof snow load:

$$p_f = 0.7C_eC_tIp_g$$

where

C_e = 1.1 (from Table 3.1)
C_t = 1.60 (from Fig. 3.1)
I = 0.9 (from Table 3.2)

Thus

$$p_f = 0.7(1.1)(1.60)(0.9)(62) = 69 \text{ lb/ft}^2$$

Sloped-roof snow load:

$$p_s = C_sp_f$$

where

$C_s = 1.0 - (40-15)/55 = 0.55$ (From Eq. (3.10))

Thus

$$p_s = 0.55(69) = 38 \text{ lb/ft}^2$$

Example B.2: A gable roof structure is located at an elevation of 5000 ft near St. Anthony in Freemont County where NGSL = 0.010 psf/ft. The building site is fully exposed to wind on all sides. It is a heated residence with R = 30, and has a composition shingle roof.

Ground snow load:

$$p_g = 0.010(5000) = 50 \text{ lb/ft}^2$$

Flat-roof snow load (Eq.(3.1)):

$$p_f = 0.7C_eC_tIp_g$$

where

C_e = 0.8 (from Table 3.1)
C_t = 1.20 (from Fig. 3.1)
I = 1.0 (from Table 3.2)

Thus

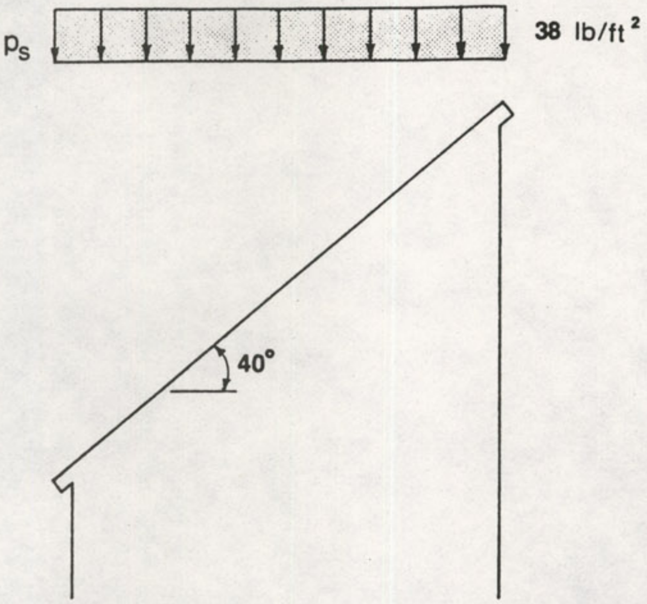

Fig. B.1 A shed roof

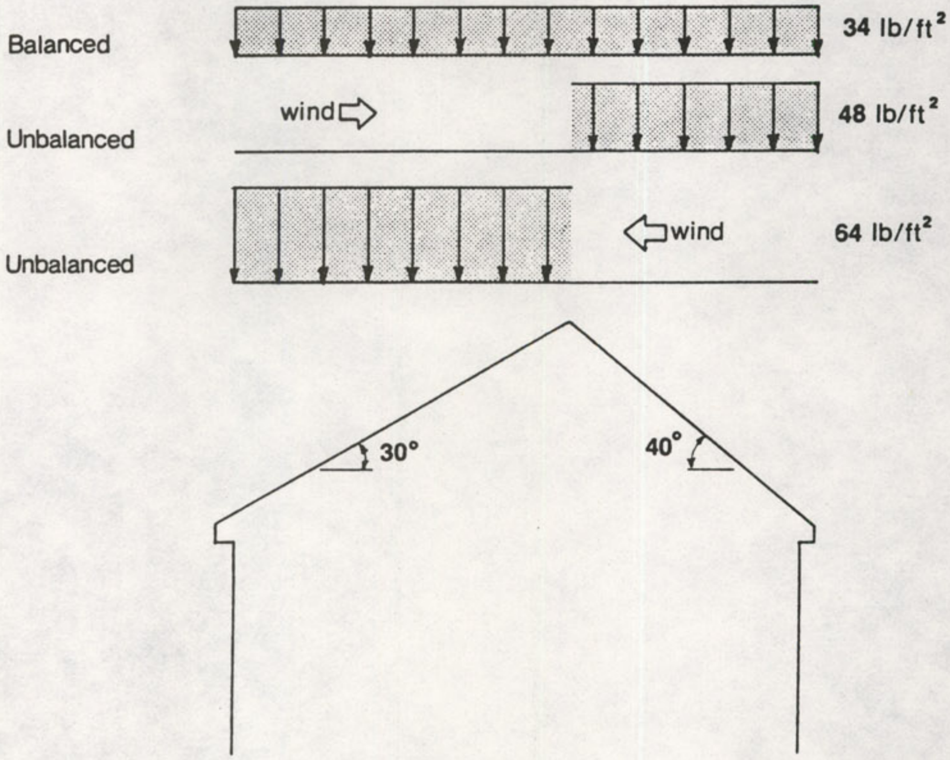

Fig. B.2 A gable roof

$$p_f = 0.7(0.8)(1.20)(1.0)(50) = 34 \text{ lb/ft}^2$$

Sloped-roof snow load:

$$p_s = C_s p_f$$

for the 30° slope

$$C_s = 1.0 \quad \text{(From Eq. (3.9))}$$

for the 40° slope

$$C_s = 1.0 - (40\text{-}30)/40 = 0.75 \text{ (From Eq. (3.9))}$$

Balanced snow load = $1.0(34) = 34 \text{ lb/ft}^2$

Unbalanced snow load (wind from left) = $1.5p_s/C_e$ (Section 3.4.1)
= $1.5(0.75)(34)/(0.8)$
= 48 lb/ft^2

Unbalanced snow load (wind from right)= $1.5p_s/C_e$ (Section 3.4.1)
= $1.5(1.0)(34)/(0.8)$
= 64 lb/ft^2

Example B.3: An arch roof structure is located at an elevation of 2750 ft near Cambridge in Washington County where NGSL = 0.031 psf/ft. The building site is fully exposed to wind on all sides. It is an unheated agricultural building with R = 5, and has a slippery metal roof.

Ground snow load:

$$p_g = 0.031(2750) = 85 \text{ lb/ft}^2$$

Flat-roof snow load (Eq.(3.1)):

$$p_f = 0.7C_e C_t I p_g$$

where

$C_e = 0.8$ (from Table 3.1)
$C_t = 1.60$ (from Fig. 3.1)
$I = 0.9$ (from Table 3.2)

Thus

$$p_f = 0.7(0.8)(1.60)(0.9)(85) = 69 \text{ lb/ft}^2$$

Sloped-roof snow load:

$$p_s = C_s p_f$$

The tangent of the line drawn from the eave to the peak = 5/20.

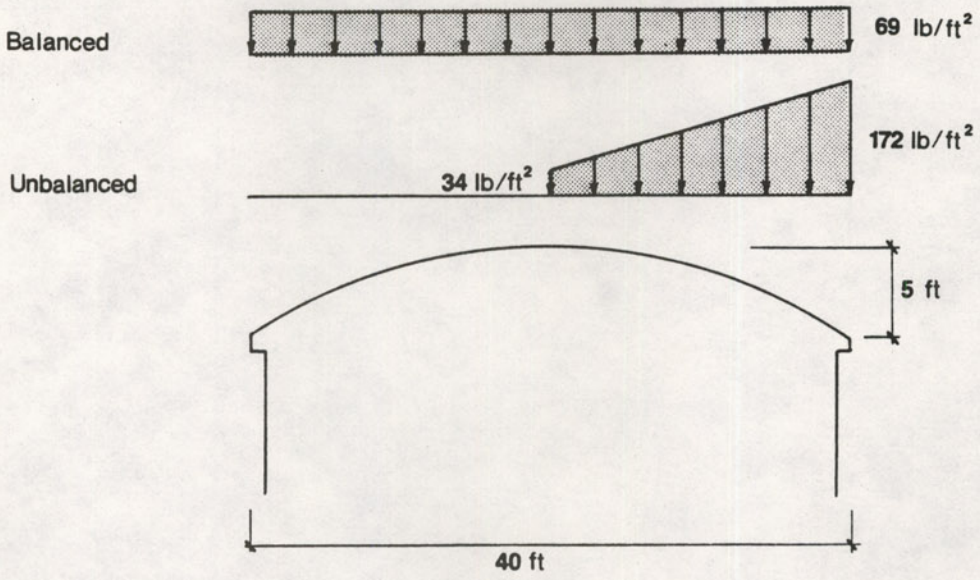

Fig. B.3 An arch roof

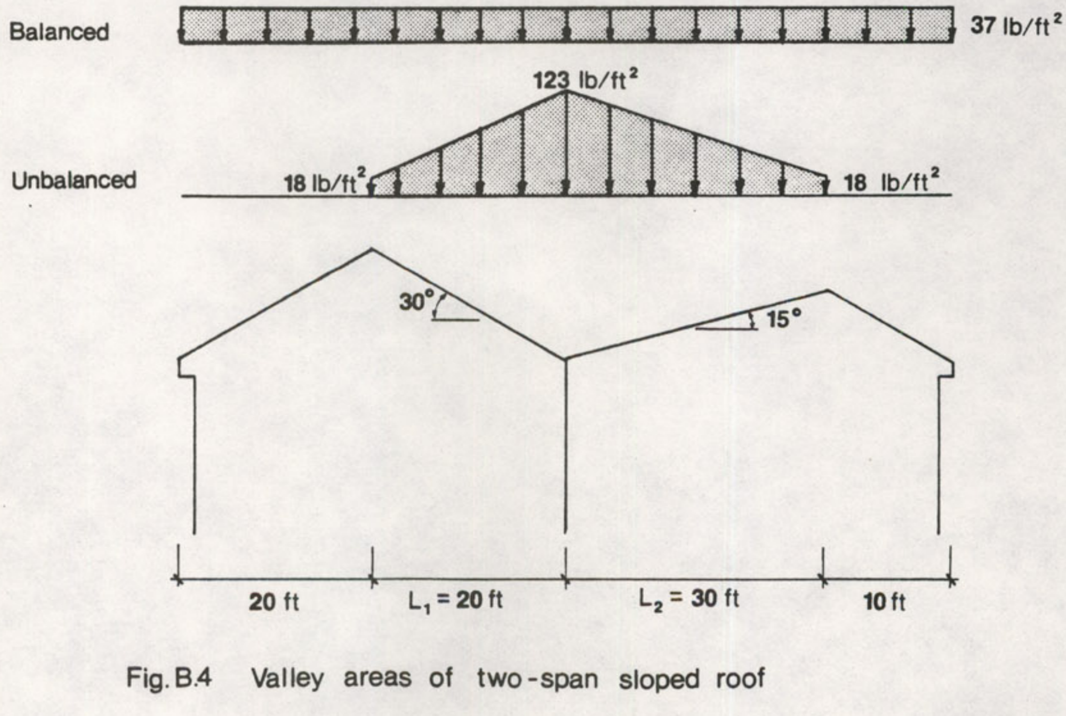

Fig. B.4 Valley areas of two-span sloped roof

Thus, the equivalent slope of the roof is 14° and $C_s = 1.0$. Since the equivalent slope is greater than 10° unbalanced loads must be considered (Section 3.4.2). $0.5p_s = 34$ lb/ft^2 and $2p_s/C_e = 172$ lb/ft^2 (see Fig. 3.4).

Example B.4: A multi-span roof structure is located at an elevation of 2100 ft near Priest River in Bonner County where NGSL = 0.035 psf/ft. The structure has a few coniferous trees around it, but it is expected the building will be exposed to winds during its lifetime. It is a heated industrial building with R = 10 and a composition shingle roof. The analysis for design snow load for the valley areas is presented.

Ground snow load:

$$p_g = 0.035(2100) = 74 \text{ lb ft}^2$$

Flat-roof snow load (Eq. (3.1)):

$$p_f = 0.7C_eC_tIp_g$$

where

$C_e = 0.9$ (From Table 3.1)
$C_t = 0.80$ (From Fig. 3.1)
$I = 1.0$ (From Table 3.2)

$$p_f = 0.7(0.9)(0.80)(1.0)(74) = 37 \text{ lb/ft}^2$$

For both 15° and 30° slopes, $C_s = 1.0$ from Eq. (3.9); thus $p_s = p_f$. $0.5p_f = 18$ lb/ft^2 and $3p_f/C_e = 123$ lb/ft^2 (See Fig. 3.5). The depth of snow at the valley is obtained using Eq. (2.1)

$$123 = 2.36h - 31.9$$

which gives h = 66 in. = 5.5 ft. Since the ridge is 8 ft above the valley the total valley load must be used (see Section 3.4.3).

Example B.5: A garage with an adjacent three-story office building is located at an elevation of 3760 ft near Twin Falls in Twin Falls County where NGSL = 0.005 psf/ft. The building site is surrounded with other buildings and trees and does not experience much wind. Both buildings have nominally flat roofs with R = 30 for the office and R = 10 for the unheated garage. The office building has a 3-ft solid parapet on all sides.

Ground snow load:

$$p_g = 0.005(3760) = 19 \text{ lb/ft}^2$$

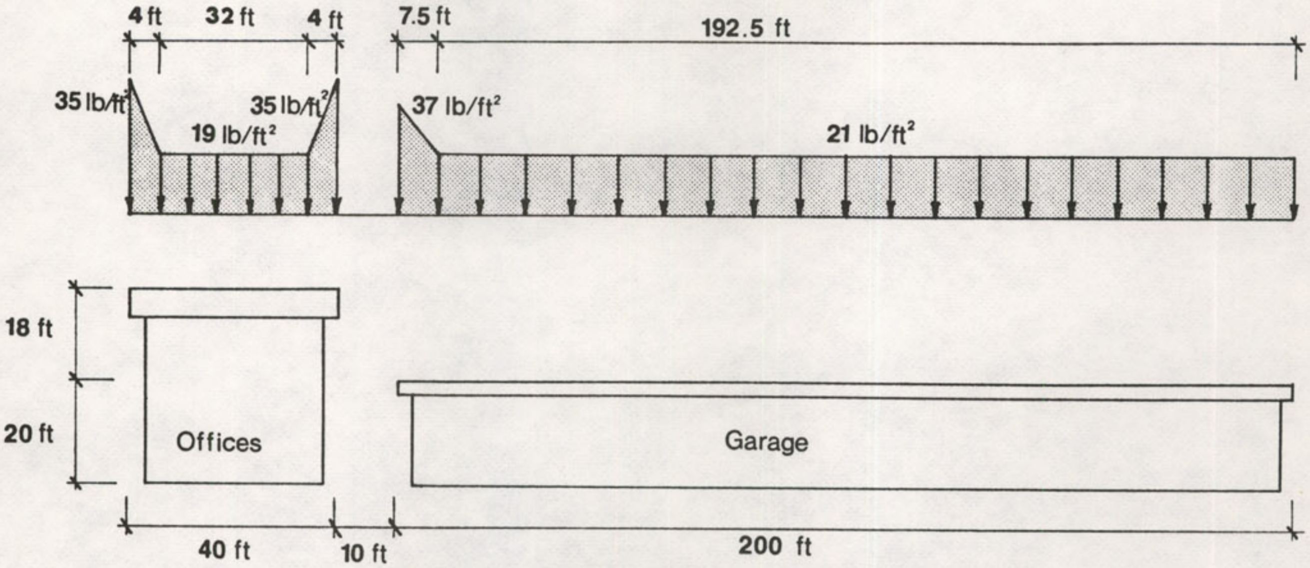

Fig. B.5 Garage with adjacent three-story office

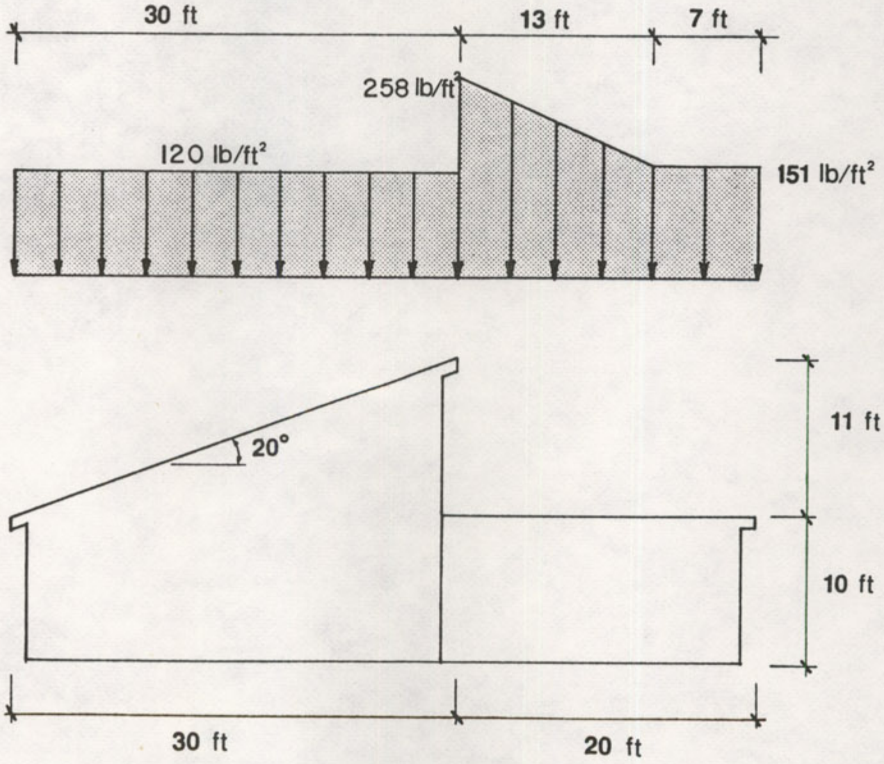

Fig. B.6 Shed roof with garage

Flat-roof snow load (Eq. (3.1)):

$$p_f = 0.7C_eC_tIp_g$$

where

C_e = 1.0 (from Table 3.1)
C_t = 1.20 for the office (from Fig. 3.1)
C_t = 1.60 for the garage (from Fig. 3.1)
I = 1.0 (from Table 3.2)

For the office:

$$p_f = 0.7(1.0)(1.20)(1.0)(19) = 16 \text{ lb/ft}^2$$

Since $p_g \leq 20$ the minimum flat-roof snow load, $p_f = Ip_g = 19$ lb/ft^2 (Section 3.1).

For the garage:

$$p_f = 0.7(1.0)(1.60)(1.0)(19) = 21 \text{ lb/ft}^2$$

Drift loading on the office roof:

L_u = 40 ft (see Section 3.6) which gives h_d = 1.0 ft (0.50 times Eq. (3.12)), and Eq. (3.13) gives γ_d = 16.5 lb/ft^3. Thus h_b = 19/16.5=1.15 ft. We note that 1.15+1.0 = 2.15<3.0; therefore, the drift will form. $(h_r-h_b)/h_b = 1.61>0.20$ so we must consider drifting.

$p_d = h_d\gamma_d = 16$ lb/ft^2.

Drift loading on the garage roof:

L_u = 40 ft, which gives h_d = 1.9 ft (from Eq. (3.12)), and in this case γ_d = 16.5 lb/ft^3. Thus, h_b = 21/16.5 = 1.27 ft. $(h_r-h_b)/h_b$ = 13>0.20 so we must consider drifting.

$$p_d = h_d\gamma_d = 32 \text{ lb/ft}^2$$

Since the buildings are separated by 10 ft,

$$p_d = 32(20-10)/20 = 16 \text{ lb/ft}^2$$

This location is one where rain on snow could occur; therefore, it is probably appropriate to add 5 lb/ft^2 to all loads. (Values on Fig. B.5 do not include rain surcharge).

Example B.6: A shed roof heated residence with an adjacent unheated garage is located at an elevation of 5010 ft near McCall in Valley County where NGSL = 0.030 psf/ft. The structure is sited in a windy area with little shelter. The residence has a smooth unobstructed metal roof with R = 40 and a slope of 20°, while R = 5 for the garage.

Ground snow load:

$$p_g = 0.030(5010) = 150 \text{ lb/ft}^2$$

Flat-roof snow load (Eq.(3.1)):

$$p_f = 0.7C_eC_tIp_g$$

where

C_e = 0.9 (from Table 3.1)
C_t = 1.40 for the residence (from Fig. 3.1)
C_t = 1.60 for the garage (from Fig. 3.1)
I = 1.0 (from Table 3.2)

Thus, for the residence;

$$p_f = 0.7(0.9)(1.40)(1.0)(150) = 132 \text{ lb/ft}^2$$

and for the garage;

$$p_f = 0.7(0.9)(1.60)(1.0)(150) = 151 \text{ lb/ft}^2$$

For the residence, $C_s = 0.91$ from Eq. (3.10), and

$$p_s = 0.91(132) = 120 \text{ lb/ft}^2$$

Drift calculations on the garage:

Using Eq. (3.12) with $L_u = 30$ ft gives $h_d = 3.2$ ft, and from Eq. (3.13) $\gamma_d = 33.5 \text{ lb/ft}^3$ giving $p_d = 107 \text{ lb/ft}^2$. This yields $h_b = 151/33.5 = 4.5$ ft and $h_d+h_b = 3.2+4.5 = 7.7 \text{ ft} < 11$. We note that $(h_r-h_b)/h_b = 1.44 > 0.2$ so drifting must be considered.

NORMALIZED GROUND SNOW LOADS for IDAHO 1986

Scale 1:1,000,000

Base map produced by Cart-O-Graphics Laboratory

Legend

Contour intervals in lb/ft²/ft

0.000 to 0.005
0.005 to 0.010
0.010 to 0.015
0.015 to 0.020
0.020 to 0.025
0.025 to 0.030
0.030 to 0.035
0.035 to 0.040
0.040 to 0.045
0.045 to 0.050
0.050 to 0.055
0.055 to 0.060
0.060 to 0.065

+ Denotes Local Exception

Obtaining Ground Snow Loads

- Select the normalized ground snow load (NGSL) for the site location. Linear interpolation between contour lines is recommended.
- Multiply the NGSL by the site elevation (in ft). This gives the ground snow load (pg) in lb/ft².
- Design loads should be specified or approved by the local building authority for locations where local records and/or experience indicate that the ground snow loads obtained from the map are inadequate.

Obtaining Roof Snow Loads

Normalized contours in lb/ft²/ft are based on a 50-year mean recurrence interval (an annual probability of exceedence of 2 percent)

- Calculate the flat-roof snow load using Eq. (3.1)

$$p_f = 0.7 C_e C_t I p_g$$

C_e comes from Table 3.1, C_t from Fig. 3.1 [or Eqs. (3.2), (3.3), and (3.4)], and I from Table 3.2.

- Calculate the sloped-roof snow load using Eq. (3.7).

$$p_s = C_s p_f$$

C_s depends upon roof thermal properties and roof geometry; values for C_s are shown in Fig. 3.2.

- Calculate effects due to unbalanced snow load, drifts, roof projections, sliding snow, rain on snow, and water accumulation.
- Apply any special design considerations such as those due to ice damming, lateral snow pressure, and roof maintenance.

Great care has been taken to be accurate in preparing this map, but the publishers cannot accept responsibility for any errors which appear or their consequences. The final design snow loads are the ultimate responsibility of the engineer, architect, local building official, and/or contractor in charge of the project.

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R. L. Sack and A. Sheikh-Taheri
Department of Civil Engineering
University of Idaho
Moscow, ID 83843

Cartography and design by Cart-O-Graphics
College of Mines and Earth Resources
Department of Geography
University of Idaho
Moscow, Idaho 83843