Recent failures point out importance of snow loads on roofs

Thorburn, H. J.; Schriever, W. R.

Publisher's version / Version de l'éditeur:

National Builder, 8, 5, pp. 18-20, 1959-06-01

NATIONAL RESEARCH COUNCIL
CANADA
DIVISION OF BUILDING RESEARCH

Recent failures point out importance of

SNOW LOADS ON ROOFS

BY H. J. THORBURN AND W. R. SCHRIEVER

Reprinted from

NATIONAL BUILDER

VOL. VIII, NO. 5, MAY, 1959, P. 18

TECHNICAL PAPER NO. 71 OF THE DIVISION OF BUILDING RESEARCH
OTTAWA
JUNE 1959

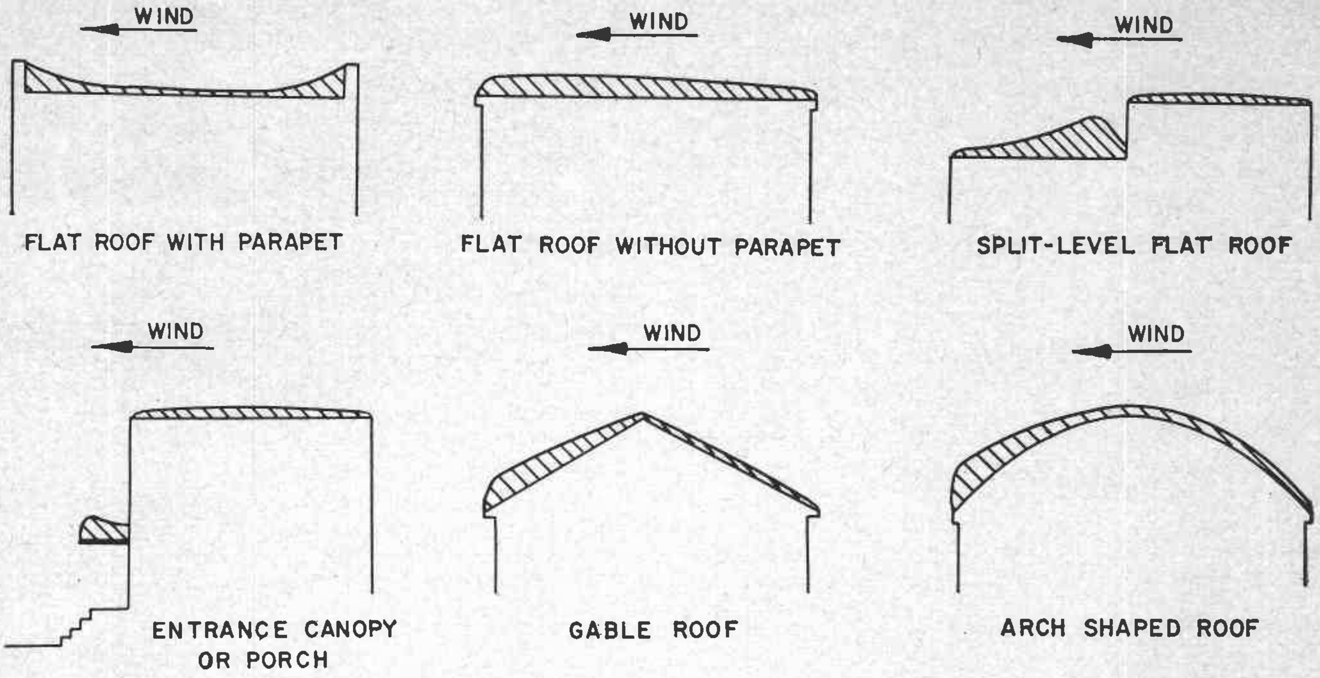
NRC 5230

Price 10 cents

This publication is being distributed by the Division of Building Research of the National Research Council as a contribution towards better building in Canada. It should not be reproduced in whole or in part, without permission of the original publisher. The Division would be glad to be of assistance in obtaining such permission.

Publications of the Division of Building Research may be obtained by mailing the appropriate remittance (a Bank, Express or Post Office Money Order or a cheque made payable at par in Ottawa to the Receiver-General of Canada, credit National Research Council) to the National Research Council, Ottawa. Stamps are not acceptable.

A coupon system has been introduced to make payments for publications relatively simple. Coupons are available in denominations of 5, 25 and 50 cents, and may be obtained by making a remittance as indicated above. These coupons may be used for the purchase of all National Research Council publications including specifications of the Canadian Government Specifications Board.



TYPICAL OBSERVED SNOW ACCUMULATIONS ON VARIOUS ROOF SHAPES

Recent failures point out importance of snow loads on roofs

The disasters at Listowel and Huntsville, Ontario, as well as other roof collapses during the past winter in different parts of Canada have highlighted as never before the dangers that heavy snow loads on roofs can create. Because of the importance of the subject to the building industry, National Builder asked DBR experts to prepare this article.

The recent numerous roof failures caused by snow loads have again reminded everyone of the danger that can be caused by heavy snow loads on roofs. In some respect it is fortunate that these reminders occur, for there is a tendency to be lulled into complacent frame of mind by several consecutive winters of normal or below normal snowfall. It is therefore obvious that careful attention to snow loads must be maintained at all times.

Although present information does not give a complete picture of the snowfall in Canada during the 1958-59 winter, it shows that for some areas it was very much above normal.

This is especially true for Southern Ontario and particularly for the area frequently referred to as the "Snow Belt"—that is the area in the lee (east) of Lake Huron.

Some observers have reported snowfall in this area to the end of February that is up to 90% above normal. Nowhere was it below normal.

It is in this snow belt that two of the winter's most serious roof failures occurred, the failure of the Listowel Memorial Arena and the failure of the Britannia Hotel curling rink near Huntsville. Apart from other factors which were mentioned during investigation, it was the snow load that "triggered" the failures.

By H. J. THORBURN
and
W. R. SCHRIEVER

In both cases the snow load was heavy. Yet the average uniform snow load in both locations was somewhat less than that specified in the 1953 issue of the National Building Code (referred to as NBC).

Structural failures in the snow belt were not limited to large roofs; many summer cottages were also crushed by the snow. On these small roofs, too, the snow loads were substantial, but somewhat less than those specified by the NBC.

Why load specification should govern roof design

It is thus obvious that the specification of snow loads for design is a most important part of any Canadian building code because in Canada snow loads are generally the largest loads to be resisted

NOTE DEFLECTION of members between columns. This is a snow load of approximately 40 lbs. per sq. ft. on an entrance canopy.

by roofs. Consequently, it is usually the magnitude of the snow load that governs the design of roofs in Canada.

Prior to the first National Building Code issued in 1941, 40 pounds per square foot was generally considered to be a suitable snow load for the populated southern part of Canada, although 30 and 50 pounds per square foot were used in a few locations.

This uniformity across the country was the result of a "follow-the-leader" trend, the leader usually being the larger cities.

Although 40 pounds per square foot was possibly based on observations in some areas, it was not until the 1941 NBC that meteorological records were used directly in calculating snow loads.

Here the load was determined by adding the average snowfall and rainfall for the months of January, February, and March. Depending on this sum, the design snow load was 20, 30 or 40 pounds per square foot.

The National Building Code, 1953, made even greater use of meteorological records in its specification for snow loads. Detailed observations of snow depth on the ground made over the ten years 1941-1950 were used.

The weight of the maximum recorded depth of snow together with the weight of the maximum 24-hour rainfall which might fall into this snow cover formed the bases for a chart giving the computed maximum snow load on a horizontal surface. The density of the snow was arbitrarily assumed as 0.2 (1/5 of the weight of water).

This chart gives lines of equal snow load on a map of Canada from which the designer can determine the specified snow load for any location.

A linear reduction of snow load is allowed for roofs of greater than 20 deg. slope, the reduction being 100 percent at 63 deg.

The Code also states that uniformly or non-uniformly distributed loads in excess of those specified in the chart shall be anticipated where shape, differences in roof levels, insulation qualities or orientation of a building, or its proximity to other buildings may cause an unusual accumulation or densification of snow.

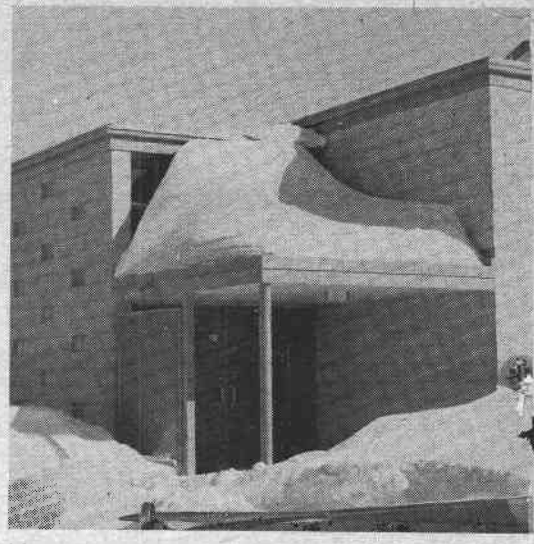
Design loads too high? — Survey will show

Although the snow load specified in the 1953 NBC is more rational than any previous Canadian specification, it has met with a certain amount of criticism.

Most of the comments were to the effect that the design loads were too high. It was claimed that measurements of snow depth on the ground were not directly applicable to the determination of roof snow loads. This was assumed because superficial observations indicate that generally snow depths on roofs are less than on the ground.

Recognizing this criticism and the influence of snow loads on the cost of roof construction, the Division of Building Research of the National Research Council began, in 1957, a countrywide survey of actual snow loads on roofs.

Because of the variation in snowfall from year to year it is unwise after only two years of observations to draw general conclusions.



DRIFTING PRODUCED this triangular accumulation of snow of 80 lbs. per sq. ft. (maximum). Door faces west.

The results to date have, however, indicated that generally, the snow load observed on roofs was less than the corresponding load on the ground.

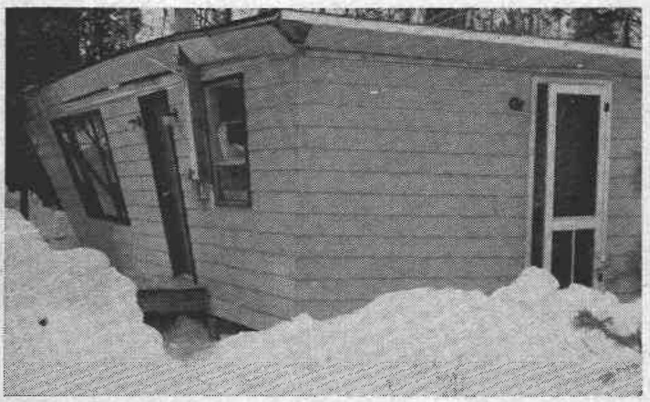
It must be emphasized, here, that this is on the average. There were frequent cases where concentrations of snow on roofs occurred to depths exceeding the depth on the ground.

A common example of this is the concentration that develops on the lower level of a split level roof, the critical point usually being at the junction of the two levels.

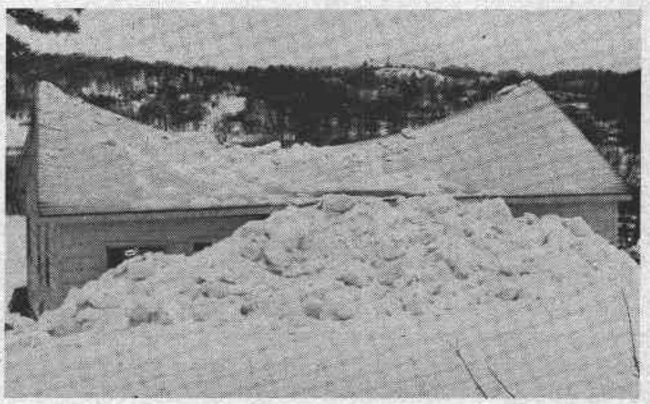
Another example is the accumulation frequently found on porch roofs or entrance canopies situated at a lower level than the main roof.

Flat roofs without parapets usually develop a fairly even snow cover unless the chimney is of such a size that it acts as a crude snow fence.

Flat roofs with parapets are subject to concentrations of snow. The centre portion of such a roof is usually covered by a layer of snow less than the ground



A COTTAGE THAT FAILED under a snow load of approximately 30 lbs. per sq. ft. because of poor ties.



A CONVENTIONALLY CONSTRUCTED HOUSE which failed under a load of approximately 40 lbs. per sq. ft.

depth. The parapet walls are banked with snow to a depth equal to the height of the wall.

Wind causes the greatest variation in snow loads in any one area. In some cases, it reduces the load. In others the reverse is true, the shape of the building and the shelter conditions being the determining factors.

Heat loss through roofs significantly reduces the snow depth, particularly of older uninsulated buildings. In newer buildings with improved insulation, the importance of this effect is reduced.

Roof failures emphasized menace of rain on snow

An unusually large number of roof failures under snow load occurred during the winter of 1958-59, especially in the snow belt of southern Ontario. Because of their fatal consequences, the failures at Listowel and Huntsville received the greatest amount of publicity. But from the point of view of snow loads, they were not outstanding.

One of the dangers emphasized by some recent failures is that of rain falling into an already heavy snow cover. When one remembers that an inch of rain is approximately equal to 10 inches of fresh snow or 5 inches of old snow the significance of this becomes apparent.

A recent investigation by the Division of Building Research indicated that the majority of the summer cottage failures in the snow belt could be attributed to poor or inadequate construction.

The snow loads under which these cottages failed were substantial. They ranged between 25 and 40 pounds per square foot. But they were below the 60-70 pound per square foot load specified by the NBC.

The most frequent structural defect contributing to the failure of these cottages was the lack or weakness of ties (ceiling joists or collar ties) between the walls. Weakness of ties was generally the result of poor or insufficient nailing.

All the cottages investigated were unoccupied and therefore unheated at the time of failure.

Although the relative lack of failures among occupied houses would tend to indicate that heat loss effectively reduced the snow load, a more probable reason is that the snow was frequently shoveled from the roofs of occupied houses. However, while the shoveling of snow from a roof reduces the possibility of failure, it is no substitute for design according to a reliable specification and for construction according to good practice.

In conclusion it may be said that practically all failures observed were due to inadequate construction or design.

Such failures should and can be avoided by designing and constructing for proper snow loads.

The preliminary results of the National Research Council's survey of snow loads on roofs indicates that the design snow loads given in the National Building Code of Canada (1953) can be regarded as a reliable guide for design.

What DBR plans to solve by survey

Main objective of the DBR country-wide survey of actual snow loads on roofs is twofold. It is to:

- Determine the relation between snow loads on the ground and snow loads on roofs.
- Assess factors which affect the accumulation of snow on roofs.

For example, it is hoped to determine the effect of wind, shape of building, heat loss, solar radiation, and shelter. It is also hoped that the survey will yield "case records" that may be of direct use to the designer in determining the loading to be expected from a given set of conditions.

In the first year of the survey measurements of snow were made at 55 locations across Canada, from Newfoundland to Vancouver Island and from the tip of Southern Ontario to Aklavik. In the survey of 1958-59 winter, snow measurements were taken at 66 locations.

The observation stations are divided into three groups, A, B, and C.

A-Stations are the back-bone of the survey located principally at universities and meteorological stations across Canada. Observers at these stations make detailed observations on two types of standard residential roofs, gable roofs and flat roofs. Depth of snow and density are measured on the roof and on the ground surrounding. These measurements are made weekly, and also after snowstorms, producing two or more inches of snow.

B-Stations, at which simpler observations are taken, cover the areas between A-Stations. They are manned by volunteer observers, usually building inspectors. Regular periodic measurements of snow depth on one roof and on the surrounding ground are made, but no density measurements. At the time of maximum snow accumulation, additional roofs are observed.

C-Stations are the same as A-Stations except for the type of roof observed. Located at a number of R.C.A.F. Stations across Canada, service personnel measure the depth and density of snow on several types of hangars and other long span roofs, as well as on the ground.

* *A list of all publications of the Division of Building Research is available and may be obtained from the Publications Section, Division of Building Research, National Research Council, Ottawa, Canada.*