Snow Accumulations in Canada: Case Histories: II

Lutes, D. A.; Schriever, W. R.

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by D. A. Lutes and W. R. Schriever

Ottawa March 1971

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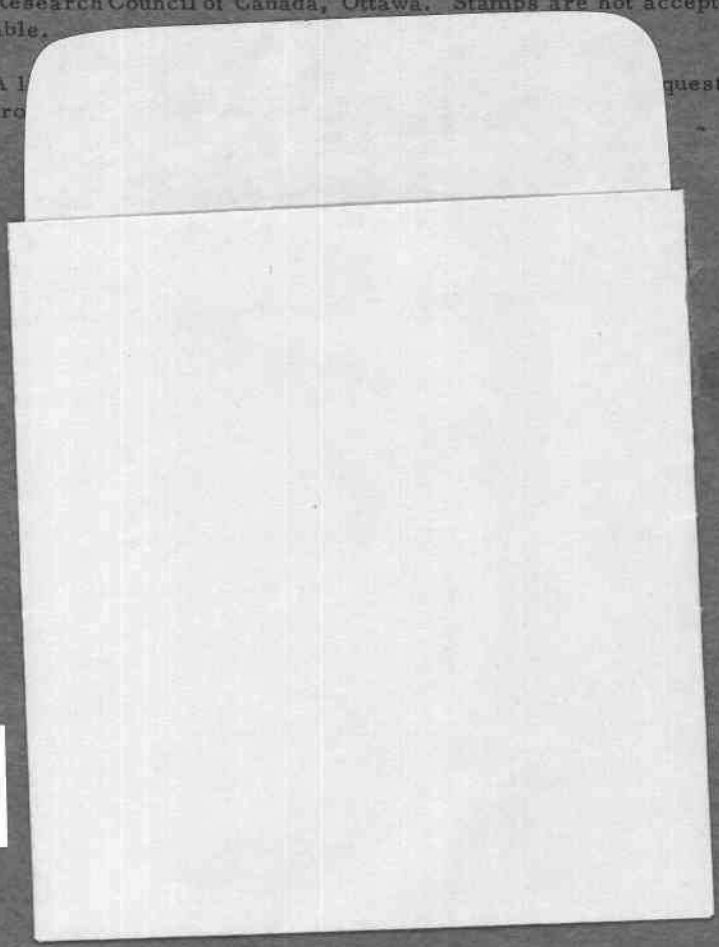

NATIONAL RESEARCH COUNCIL OF CANADA
DIVISION OF BUILDING RESEARCH

SNOW ACCUMULATIONS IN CANADA
CASE HISTORIES : II

Compiled by

D. A. Lutes and W. R. Schriever

Technical Paper No. 339
of the
Division of Building Research

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The influence of wind and other factors on snow loads on roofs has been recognized in the National Building Code of Canada since 1965. Guidance is provided in the 1970 edition of the Code in the chapter, "Coefficients for Snow Loads on Roofs," in Supplement No. 4, Canadian Structural Design Manual.

This guidance, however, can deal only with the most common types and shapes of roofs, and it should be remembered that the designer is responsible for making the best possible estimate of the probable snow load. To assist with unusual types of roofs and conditions a collection of case histories, "Snow Accumulations in Canada, Case Histories : I" was published in January 1967 (NRC 9287). Case Histories : II is an expansion and amplification of Case Histories : I. Descriptions and photographs of fourteen unusual snow load accumulations are presented. The explanation of the determination of minimum design snow loads for Canada, contained in NRC 9287, is also included in this report (see Appendix A).

Further additions will be published when a sufficient number of new observations have been collected. Reports of large or peculiar snow loads and roof failures that may occur during the coming winters would therefore be very welcome. Special B-Station cards for recording information are available from Building Structures Section, Division of Building Research, National Research Council, Ottawa 7, Ontario.

LIST OF CASE HISTORIES

Case History No.	Location	Roof Description					Page
		Flat	Sloped	Arched	Multi-Level	Other	
67 - 23	Mica Creek Village, B.C.		X				4, 5
67 - 24	Ottawa, Ontario	X			X		4, 5
67 - 25	Ottawa, Ontario	X			X		6
67 - 26	Mica Creek Village, B.C.	X			X	X	6
67 - 27	Glacier National Park, B.C.		X				7
67 - 30	Ottawa, Ontario	X			X	X	7, 8
68 - 1	Ottawa, Ontario	X			X		9
69 - 1	Arvida, P.Q.	X			X		9, 10
69 - 2	Saskatoon, Sask.	X			X		11
69 - 3	Quebec City, P.Q.	X			X		11
70 - 1	Montreal, P.Q.	X			X		13
70 - 2	Montreal, P.Q.	X			X		13
70 - 3	Montreal, P.Q.	X			X		14, 15
70 - 4	Montreal, P.Q.	X			X	X	15

Date 28 January 1967
Location Mica Creek Village, B.C.

Failure: No
Accumulation: Yes

No: 67-23

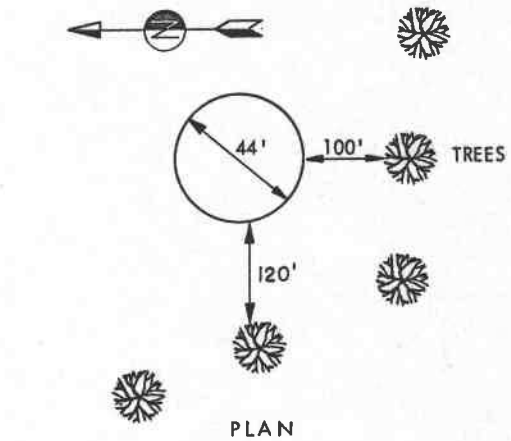
ROOF AND BUILDING DESCRIPTION

Type of structure and use: Circular water tank on ground.

Building Heated: No Roof Insulated: No

Shelter Conditions: Sheltered on two sides by 50-ft trees 100 ft from tank.

ROOF DESCRIPTION



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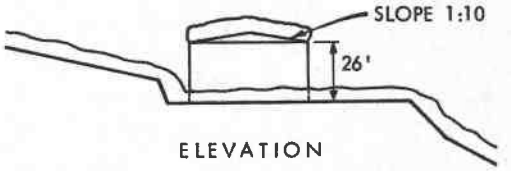


ELEVATION

ROOF SNOW LOADS (psf)

Basic NBC (1970): 112
Avg. Obsd.: 146

Max. Obsd.:

GROUND SNOW LOADS (psf)

NBC (1970): 140
Avg. Obsd.: 150

SNOW LOAD DISTRIBUTION

Very uniform distribution of snow on both roof and ground. Location of ground snow measurement was 210 ft below elevation of water tank roof. Winter with exceptional snowfall.

Date 31 January 1967
Location Ottawa, Ontario

Failure: No
Accumulation: Yes

No: 67-24

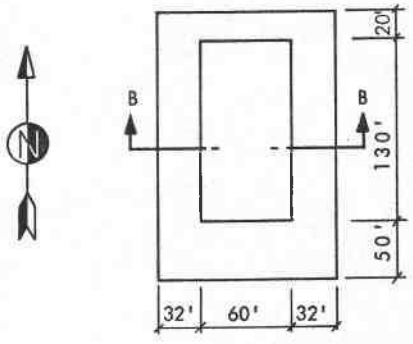
ROOF AND BUILDING DESCRIPTION

Type of structure and use: Large flat roof with 60- by 130-ft raised portion. Warehouse.

Building Heated: No Roof Insulated: No

Shelter Conditions: Building exposed. Lower roof sheltered by raised portion.

ROOF DESCRIPTION



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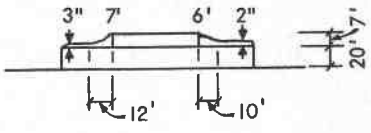


SECTION B-B

ROOF SNOW LOADS (psf)

Basic NBC (1965): 36
Avg. Obsd.:

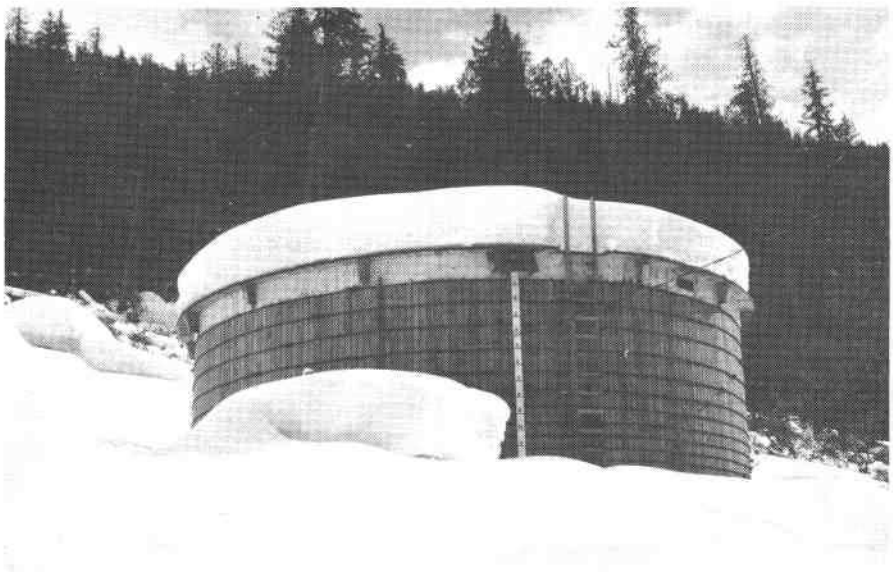
Max. Obsd.: 111

GROUND SNOW LOADS (psf)

NBC (1965): 60
Avg. Obsd.: 27

SNOW LOAD DISTRIBUTION

Raised portion of roof covered with less than 2 in. of snow. Triangular drifts on the lower roof of a maximum depth of 7 ft on the west side of raised portion and 6 ft on the east side of raised portion.



67-23 Very uniform snowcover on circular water tank in calm mountain area. Slope 1:10 (Courtesy CASECO Consultants Ltd.)

67-24 Triangular drift 6 ft deep on main roof adjacent to large raised portion.

Date 3 February 1967
Location Ottawa, Ontario

Failure: No
Accumulation: Yes

No: 67-25

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Large flat roof of warehouse with lower flat roof of office.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Building exposed. Lower roof sheltered on two sides by high roof.

ROOF SNOW LOADS (psf)

Basic NBC (1965): 36
Avg. Obsd.:

Max. Obsd.: 120

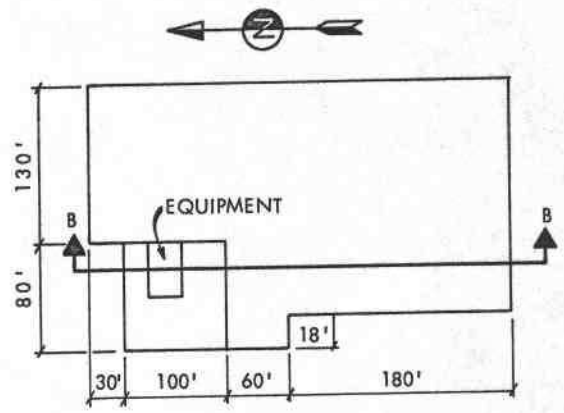
GROUND SNOW LOADS (psf)

NBC (1965): 60
Avg. Obsd.: 27

SNOW LOAD DISTRIBUTION

Heavy drifting on lower roof to a maximum height of 7 ft.

ROOF DESCRIPTION



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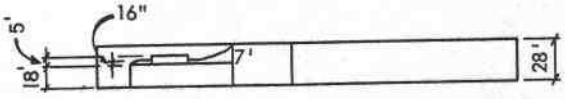


SECTION B-B

Date 14 February 1967
Location Mica Creek Village, B.C.

Failure: No
Accumulation: Yes

No: 67-26

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Three flat roofed buildings.

Building Heated: No Roof Insulated: No

Shelter Conditions: Buildings sheltered by 40-ft trees.

ROOF SNOW LOADS (psf)

Basic NBC (1970): 112
Avg. Obsd.: 123

Max. Obsd.:

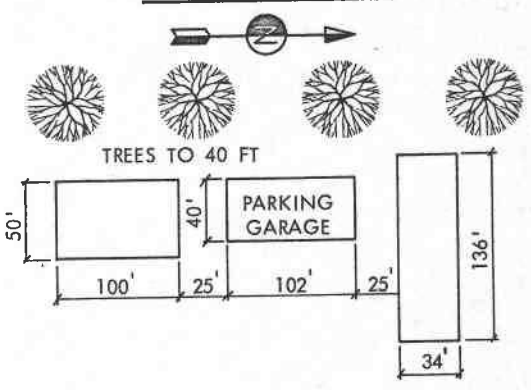
GROUND SNOW LOADS (psf)

NBC (1970): 140
Avg. Obsd.: 165

SNOW LOAD DISTRIBUTION

Uniform distribution on all buildings.

ROOF DESCRIPTION



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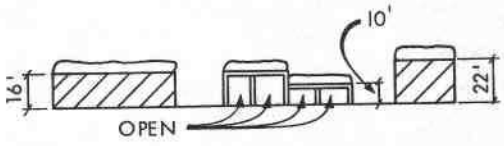


ELEVATION

Date 20 February 1967
Location Glacier National Park, B.C.

Failure: No
Accumulation: Yes

No: 67-27

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Low-slope roof. Kitchen shelter.

Building Heated: No Roof Insulated: No

Shelter Conditions: Building sheltered.

ROOF SNOW LOADS (psf) GROUND SNOW LOADS (psf)

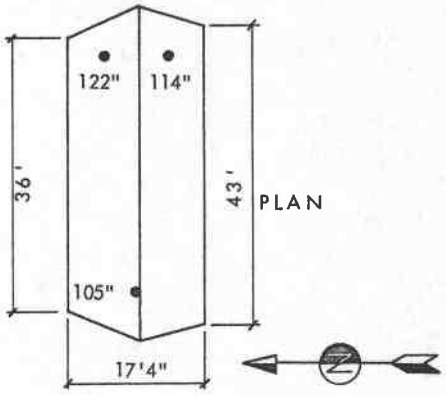
Basic NBC (1965): 129 NBC (1965): 161
Avg. Obsd.: 187 Avg. Obsd.: 208

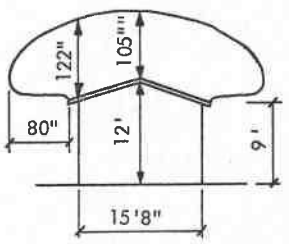
Max. Obsd.: 200

SNOW LOAD DISTRIBUTION

Fairly uniform distribution with large snow overhangs at eaves and cable ends.

ROOF DESCRIPTION





ELEVATION

Date 22 February 1967
Location Ottawa, Ontario

Failure: No
Accumulation: Yes

No: 67-30

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Large flat roof with large canopy. Retail store.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Building exposed. Canopy sheltered by high roof.

ROOF SNOW LOADS (psf) GROUND SNOW LOADS (psf)

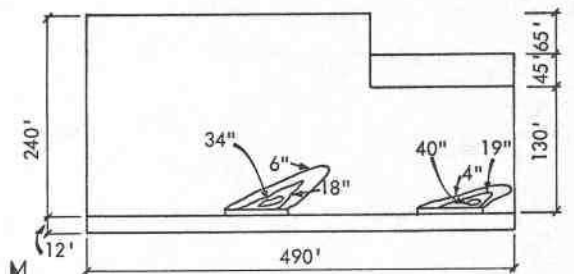
Basic NBC (1965): 48 NBC (1965): 60
Avg. Obsd.: 5 Avg. Obsd.: 25

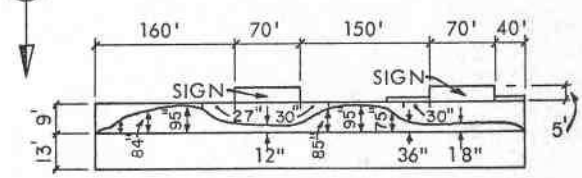
Max. Obsd.: 120 (on canopy)

SNOW LOAD DISTRIBUTION

Large drifts on canopy and behind signs.

ROOF DESCRIPTION





ELEVATION

BR4717-3

67-30 Front view of large drifts on canopy adjacent to higher main roof. Note effect of sign on snow accumulation.

Date 17 January 1968
Location: Ottawa, Ontario

Failure: No
Accumulation: Yes

No: 68-1

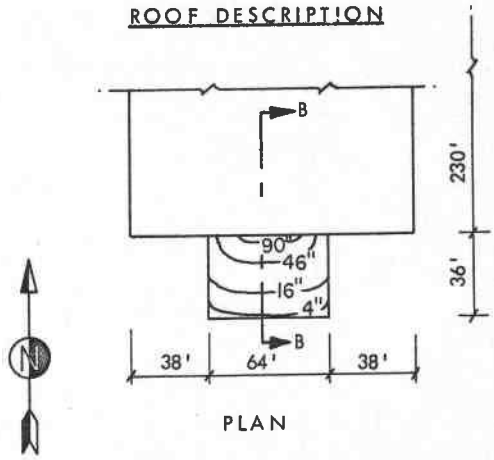
ROOF AND BUILDING DESCRIPTION

Type of structure and use: Multi-level flat roof. Warehouse and office.

Building Heated: Lower only Roof Insulated: Lower only

Shelter Conditions: Building exposed. Lower roof sheltered by high roof.

ROOF DESCRIPTION



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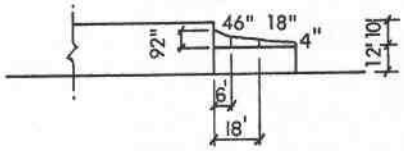


SECTION B-B

ROOF SNOW LOADS (psf)

Basic NBC (1965): 36
Avg. Obsd.: 22

Max. Obsd.: 81

GROUND SNOW LOADS (psf)

NBC (1965): 60
Avg. Obsd.: 9

SNOW LOAD DISTRIBUTION

Drift formed on lower roof in lee of large high roof. Average snow load on high roof 3 psf.

Date 4 January 1969
Location Arvida, Quebec

Failure: No
Accumulation: Yes

No: 69-1

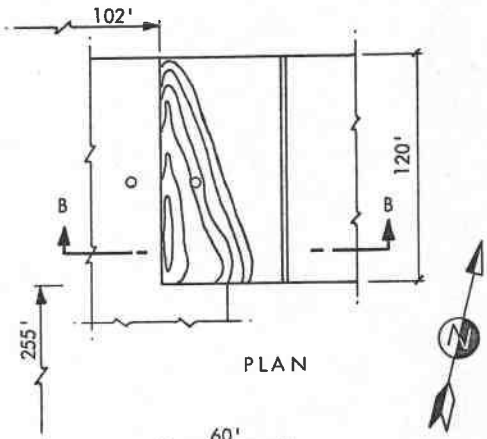
ROOF AND BUILDING DESCRIPTION

Type of structure and use: Multi-level roof. Storage building.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Building exposed. Lower roof sheltered from two sides.

ROOF DESCRIPTION



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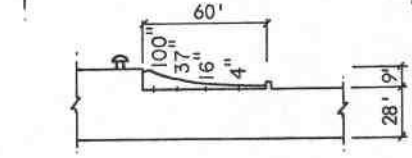


SECTION B-B

ROOF SNOW LOADS (psf)

Basic NBC (1965): 45
Avg. Obsd.:

Max. Obsd.: 160

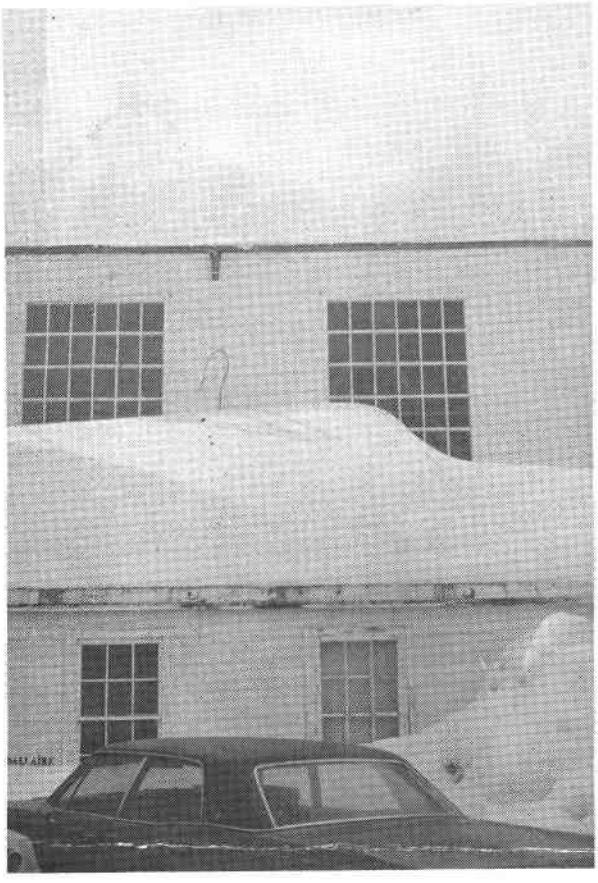
GROUND SNOW LOADS (psf)

NBC (1965): 75
Avg. Obsd.: 21

SNOW LOAD DISTRIBUTION

Large drift on lower roof caused by prevailing winds which deposit snow from large high roof.

69-1 Drifts up to 10 ft on lean-to roof adjacent (west) to higher main roof. (Courtesy of M. Drouin.)



69-1 Front view of triangular drift 11 ft deep on lean-to roof adjacent (east) to higher main roof. (Courtesy of M. Drouin.)

Date 21 February 1969
Location Saskatoon, Saskatchewan

Failure: No
Accumulation: Yes

No: 69-2

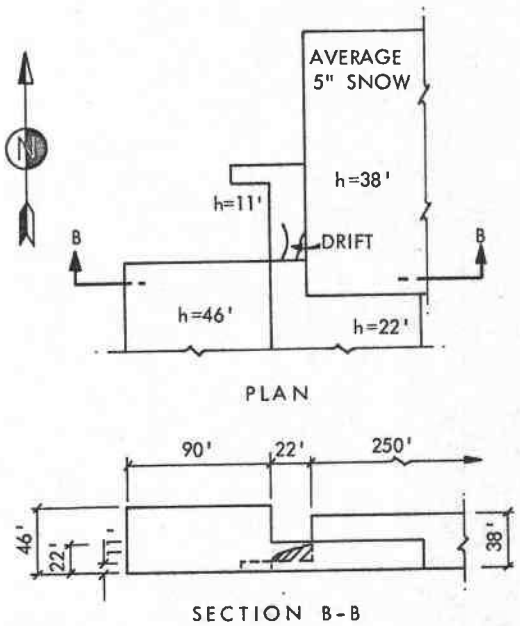
ROOF AND BUILDING DESCRIPTION

Type of structure and use: Multi-level roof Gymnasium.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Building exposed. Lower roof sheltered by high roofs.

ROOF DESCRIPTION



ROOF SNOW LOADS (psf)

Basic NBC (1965): 21
Avg. Obsd.:
Max. Obsd.: 180

GROUND SNOW LOADS (psf)

NBC (1965): 35
Avg. Obsd.: 33

SNOW LOAD DISTRIBUTION

No snow observations made on lower roofs except for 8-ft drift shown in sketch. Ground depths varied from 15 to 35 in.

Date 14 March 1969
Location Quebec City, Quebec

Failure: No
Accumulation: Yes

No: 69-3

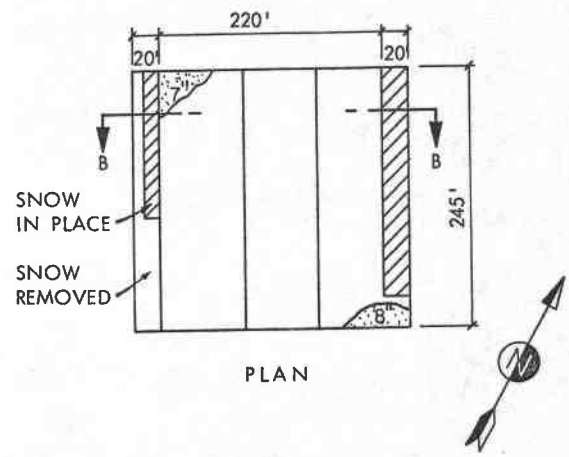
ROOF AND BUILDING DESCRIPTION

Type of structure and use: Roof with two lower lean-to sections west and east of main roof. Airplane hangar.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Building exposed. Lower roofs sheltered on one side by upper roof.

ROOF DESCRIPTION



ROOF SNOW LOADS (psf)

Basic NBC (1965): 50
Avg. Obsd.: 198
Max. Obsd.: 238

GROUND SNOW LOADS (psf)

NBC (1965): 84
Avg. Obsd.: 52

SNOW LOAD DISTRIBUTION

Maximum loads of 238 and 221 psf on lower roofs east and west, respectively, of large high roof. High roof virtually clear of snow. This case illustrates the need to consider all wind directions.

Date 30 December 1969
Location Montreal, Quebec

Failure: No
Accumulation: Yes

No: 70-1

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Multi-level roof. Warehouse and office.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Building exposed. Lower roof sheltered by high roof.

ROOF SNOW LOADS (psf)

Basic NBC (1965): 32
Avg. Obsd.:

Max. Obsd.: 110

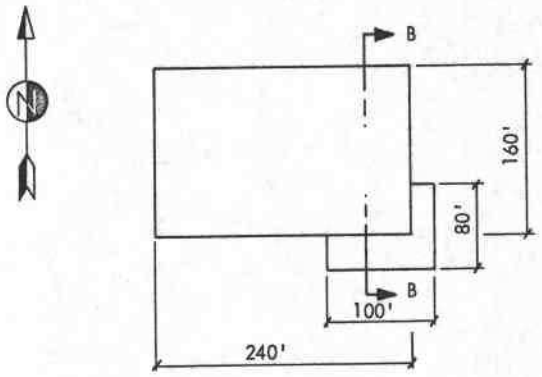
GROUND SNOW LOADS (psf)

NBC (1965): 54
Avg. Obsd.: 20

SNOW LOAD DISTRIBUTION

Little snow on main roof with large accumulation on lower roof due to single snowstorm on 26 and 27 December.

ROOF DESCRIPTION



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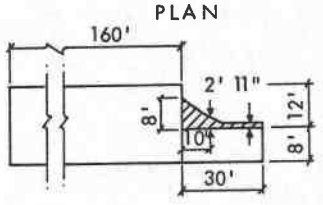


SECTION B-B

Date 30 December 1969
Location Montreal, Quebec

Failure: No
Accumulation: Yes

No: 70-2

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Multi-level roof with two long canopies. Warehouse and office.

Building Heated: No Roof Insulated: No

Shelter Conditions: Building exposed. Portion of lower roof sheltered by high roof.

ROOF SNOW LOADS (psf)

Basic NBC (1965): 32
Avg. Obsd.:

Max. Obsd.: 83

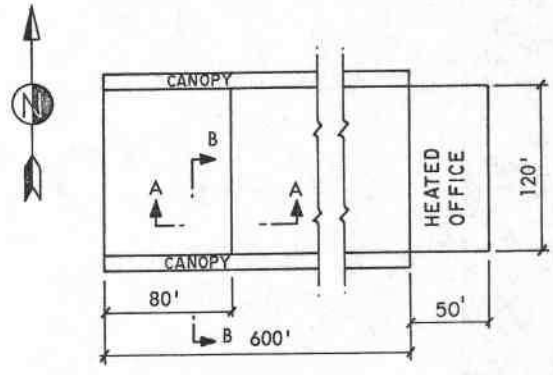
GROUND SNOW LOADS (psf)

NBC (1965): 54
Avg. Obsd.: 20

SNOW LOAD DISTRIBUTION

Triangular drifts up to 6 ft on lower roof and south canopy. Approximately 4 in. of snow on high roof and 1 ft on exposed portion of lower roof.

ROOF DESCRIPTION



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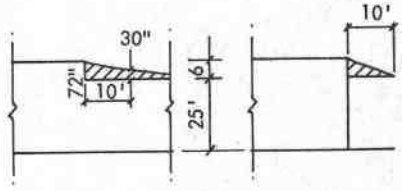
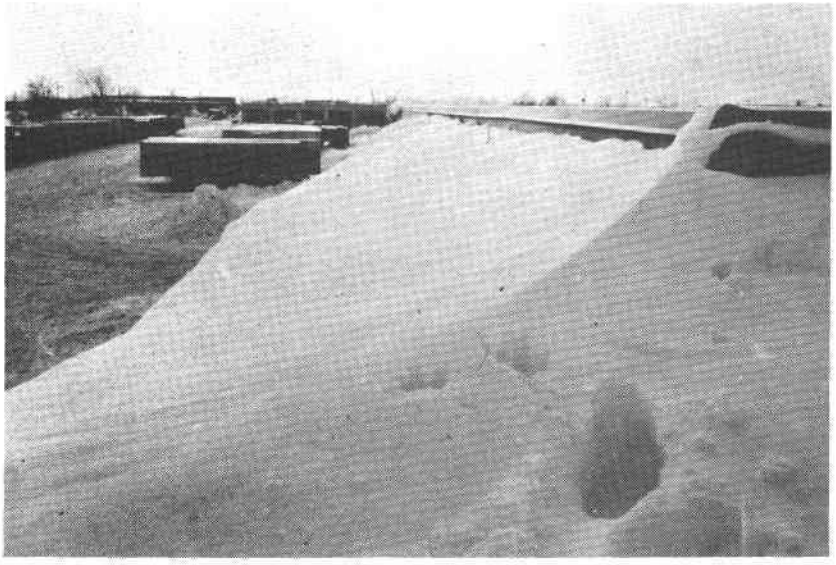


SECTION A-A SECTION B-B

70-1 Side view of drift 8 ft deep on roof adjacent to higher, very large flat roof.



70-2 Triangular drift on canopy adjacent to higher large flat roof.

Date 30 December 1969
Location Montreal, Quebec

Failure: No
Accumulation: Yes

No: 70-3

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Multi-level roof. Warehouse and office.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Building exposed. Lower roof sheltered by high roof.

ROOF SNOW LOADS (psf)

Basic NBC (1965): 32
Avg. Obsd.:

Max. Obsd.: 96

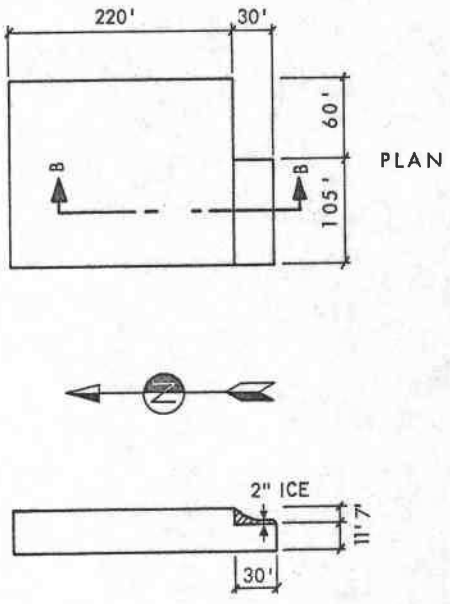
GROUND SNOW LOADS (psf)

NBC (1965): 54
Avg. Obsd.: 20

SNOW LOAD DISTRIBUTION

Approximately 3 in. slush plus 3 in. snow on main roof. Triangular drift on lower roof up to 7 ft. Snow accumulation was the result of a single storm on 26 and 27 December 1969.

ROOF DESCRIPTION



Date 30 December 1969
Location Montreal, Quebec

Failure: No
Accumulation: Yes

No: 70-4

ROOF AND BUILDING DESCRIPTION

Type of structure and use: Large flat roof with three barrel canopies over front entrance.

Building Heated: Yes Roof Insulated: Yes

Shelter Conditions: Main roof sheltered by higher roofs of neighboring buildings. Lower roof sheltered by higher roof.

ROOF SNOW LOADS (psf)

Basic NBC (1965): 43
Avg. Obsd.: 10(upper)

Max. Obsd.: 80

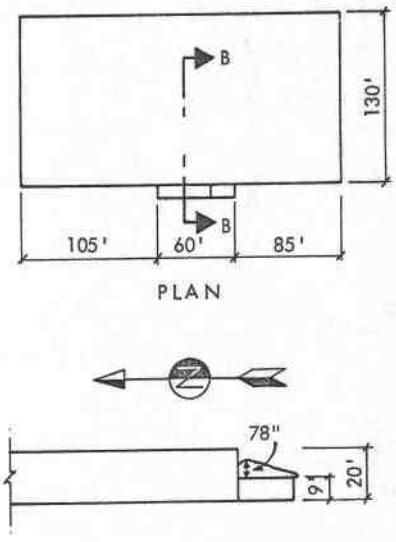
GROUND SNOW LOADS (psf)

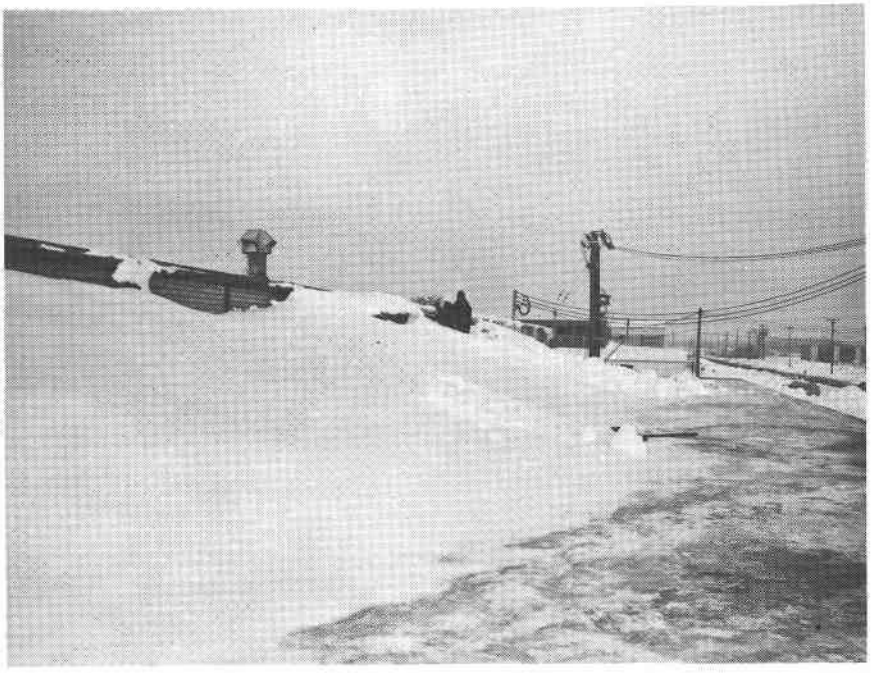
NBC (1965): 54
Avg. Obsd.: 20

SNOW LOAD DISTRIBUTION

Small snow load (10 psf) on upper roof with large accumulation up to $6\frac{1}{2}$ ft on the barrel canopies.

ROOF DESCRIPTION





70-3 Large triangular drift on roof adjacent to higher, very large roof.

70-4 Large drifts on barrel canopies adjacent to higher, very large flat roof.

APPENDIX A

DETERMINATION OF MINIMUM DESIGN SNOW LOAD

The minimum design snow load, s, on the roof or any other area above ground which is subject to snow accumulation is obtained by multiplying the snow load on the ground, g, specified for the municipality or area* considered, by the snow load coefficient (shape factor), C_s, applicable to the particular roof area considered.

$$s = C_s g$$

where

s = design snow load, psf
g = ground snow load, psf
C_s = snow load coefficient.

The basic snow load coefficient is 0.8, except that for roofs exposed to the wind, under certain conditions described below, this value may be reduced to 0.6. These coefficients are to be modified (increased or decreased) to account for the following influences:

(a) decrease of snow loads because of the effect of slope for roof slopes exceeding 30°;

(b) accumulation of unbalanced snow loads on gable and hip roofs;

(c) accumulation of nonuniform and unbalanced snow loads on arched and curved roofs;

(d) accumulation of increased snow loads in valleys of butterfly as well as multispan curved or sloped roofs;

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*Recommended ground snow loads and other climatic information for building design for many municipalities in Canada are published in Supplement No. 1 to the National Building Code of Canada. Values for other locations in Canada may be obtained from the Secretary of the Associate Committee on the N.B. C., National Research Council, Ottawa.

(e) accumulation of increased nonuniform snow loads due to drifting snow on the lower of two-level or multi-level roofs, such as a canopy, marquee or porch roof, provided the upper roof is part of the same building or of an adjacent building not more than 15 feet away;

(f) accumulation of increased nonuniform snow loads on areas adjacent to roof projections, such as penthouses, large chimneys, and ventilating equipment;

(g) accumulation of increased snow or ice loads on areas due to snow sliding onto these areas from an adjacent roof sloping towards this area or due to melt water draining onto it. The magnitude and distribution of the increase should be appropriate to the relative positions and sizes of the surfaces.

EXPOSED ROOFS

Numerous observations, in many areas of Canada, have shown that where a roof, or part of a roof, is fully exposed to wind, part of the snow is blown off under most conditions. The coefficients for such exposed roofs may be reduced by 25 per cent (from 0.8 to 0.6) if the following conditions are fulfilled:

(a) The roof is fully exposed to the winds on all sides, that is, not shielded on any side from the direct action of the wind by numerous trees higher than the roof, or by higher roofs of the same or of neighbouring buildings.

(b) The roof does not have projections, such as parapet walls, which prevent the snow from being blown off.

(c) The building is not located in a region of low winter season wind speeds.

INFLUENCE OF SHAPE OF ROOF

Snow load coefficients, C_s, for some fairly common roof shapes are given in Figures 2-1 to 2-7, of Chapter 2, "Coefficients for Snow Loads on Roofs," of Supplement No. 4 to the N.B.C.; explanations on their use appear in Sections III and IV on pages

32 to 36 of the Appendix to the Supplement. Somewhat naturally only the more common shapes of roofs have been covered in the Supplement. Every designer should try to obtain the latest and most appropriate information available and, consequently, other snow load coefficients, if considered to be more appropriate in a particular case and if based on applicable field observations or on model tests, should be used in lieu of, or in addition to, those given in the Supplement.