Snow loads on roofs 1957-58: second progress report

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DIVISION OF BUILDING RESEARCH

SNOW LOADS ON ROOFS 1957-58

SECOND PROGRESS REPORT

by

D.E.Allen and C.J. Turkstra

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Ottawa

November 1958

PREFACE

The critical load for which the roofs of buildings and houses in Canada generally must be designed is the load imposed by snow. Thus the magnitude of the design snow load has a considerable effect on the cost of roof constructions.

Snow loads to be expected across Canada are given in the National Building Code (1953) in a map from which the design snow load can be obtained for any region. The loads shown on this map were based on measurements of maximum snow depths on the ground from records taken over a ten-year period at a number of points across the country. Opinion has been widely expressed that measurements of snow depths on the ground cannot be applied directly to the determination of design snow loads for roofs and that the snow load values given in the 1953 Code are too high for some regions.

The Associate Committee on the National Building Code is responsible for the preparation and revision of the Code. As a service to this Committee, the Division of Building Research of the National Research Council undertook to study actual snow loads as they occur on roofs. This study, because of regional and yearly climatic variations, must extend over several years and must take into account the whole of Canada.

This report is the second progress report on the survey of snow loads on roofs, the first, (DBR Report No. 134), having covered only the pilot survey which was carried out during the first winter of observations. This, therefore, is the first report of the full survey, giving the results obtained by the three types of stations taking part in the work (A, B and C Stations). The records are shown mainly in graphical form. The report also discusses trends and unusual features of the observations of the winter. An appendix tells of the handling of snow loads in Russia, illustrating that engineers in another country with a cold climate are encountering similar problems.

Ottawa
November 1958

Robert F. Legget,
Director.

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In 1956 the Division of Building Research began a survey of snow loads on roofs across Canada for the Associate Committee of the National Building Code. The purpose of this survey is to obtain records over a number of years of actual roof loads in order to provide a basis for more rational design snow loads in the National Building Code in the future. At present the design snow loads are based on snow measurements on the ground only. A more complete description of the background for this survey and the results of a pilot survey taken in the first year are presented in DBR Reports 106 and 134.

The purpose of this and future yearly progress reports is to summarize the findings of one winter's observations and to point out any trends and unusual features of the observations. In addition, this report suggests a method of presentation of the year's observations and discusses the problem of loading pattern by comparing specifications with actual occurrences.

As an example of the use of a non-uniform loading pattern in a building code an excerpt from the Russian "Construction Standards and Regulations" is given in an appendix. Included also in the appendix are abstracts from 2 Russian articles discussing the snow loads in the Russian standards. These may illustrate that engineers in another country with cold winters are encountering similar code problems.

Summary of 1957-58 Observations

Few of the stations at which snow loads or depths were measured had average or above average yearly snowfall. A number of stations had almost negligible snow accumulations on roofs. The maximum recorded average ground and roof loads were 120 psf and 82 psf both observed at the A Station, Glacier, B.C. (4,100 ft above sea level). The year's measurements confirmed the impression that there is an appreciable difference between roof and ground snow loads. In all but a few special cases roof loads were lighter. As expected, however, large snow concentrations occurred on some roofs, particularly along the parapets of flat roofs, on the lower portions of stepped roofs and in roof valleys. These localized drifts were often deeper and heavier than the snow load on the ground.

Description of Stations

Fifty-five stations reported in the 1957-58 surveys (15 A, 32 B and 8 C Stations). The three types of stations and the procedures used were described in DBR Report No. 134. In brief, at the A Stations detailed roof and ground depths and densities were recorded weekly and after snowstorms on relatively conventional sloped and flat roofs according to the field instructions issued in DBR Technical Note No. 233. At B Stations only roof and ground depths were measured, weekly and after large snowfalls. B Station observers recorded the deepest roof drift and a number of representative snow depths on a building (avoiding drifts and bare spots). In addition, observers were asked to record some general information on wind and climate along with observations of extreme snow accumulations in the area.

At C Stations the R.C.A.F. made measurements similar to those of the A Stations on large roofs at 9 bases across the country. Where possible four standard buildings were used at each station - a cantilever hangar (flat roof), an arch hangar (curved roof), a mechanical equipment garage (flat roof) and a supply depot (flat roof) (Fig. 12). For each type of roof a number of points had been chosen at which snow depths were measured weekly by means of a yardstick. These were accompanied by density and ground depth measurements

Presentation of Results

At the A and C Stations snow loads could be readily determined because both depth and density measurements were available. For each building the maximum, average and minimum roof loads and the average ground load were plotted for each day of observation. The locations of the extreme loads are noted because the maximum load did not always occur at the same gauge. These plots are given in Figs. 1 to 15. Only stations having more than 5 in. of accumulated snow during the winter are shown. Results for all station roofs are summarized in Table I (A Stations) and Table II (C Stations) which give the maximum average roof and ground loads, the maximum observed roof load (deepest drift) and the N.B.C. design snow load for comparison.

Figures 1 to 15 also show some detail of the buildings observed together with the maximum daily wind speed and direction, average daily temperature and the total hours of bright sunshine which were taken from the Department of Transport Meteorological Summaries for each station.

At the B Stations maximum roof and ground loads were estimated assuming a density of 0.2. To summarize those results the loads were represented on a map of Canada (Fig. 16). As a final summary of the observations for the A and C Stations a similar map was prepared (Fig. 17).

Discussion of 1957-58 Observations

As previously noted average roof loads were less than were average ground loads. The loads were usually not distributed uniformly over the roof area. In the following notes some special features of a few of the observations are discussed.

Aklavik: (An example of a long continuous winter with low winds)

This is one of the few stations at which snowfall was above average for the winter. Because of the very low temperature, the lack of sunshine, and the comparatively low wind velocities, snow accumulated on the roofs for several months. This is very unusual for Aklavik. The average roof load, however, was always a good deal less than the ground load. The snow distribution was fairly even over both the roofs observed at this station (Figs. 1 and 18).

Glacier: (An example of very deep snow typical of some mountain regions in B.C.)

On most of these sloped roofs the snow did not accumulate for long periods but slid off quickly (Figs. 2 and 3). The Alpine Club Lodge shown in Fig. 19 is a case of a completely sheltered, unheated gable roof. A roof load of 82 psf was reached on this building before the snow was removed, compared to a measured ground load of 120 psf. If this measured ground load is compared with the reduction factor of the National Building Code for a 45° pitch there is a design load of 69 psf. This serves to show the extremes which are possible under special conditions particularly in mountain areas (for a discussion of snow loads in mountains refer to DBR Report No. 162). In Glacier large accumulations of ice and creeping snow were observed along the eaves and overhanging the eaves. No other station recorded this phenomenon.

Montreal: (An example of a low roof between two high buildings)

In Montreal during this winter, high winds (average hourly speeds up to 40 mph) and relatively high temperatures resulted in very short retention periods for the snow on the various roofs (Fig. 4). For the flat roof situated between two higher buildings a heavy snow accumulation occurred at the rear parapet, probably caused by wind funnelling between the buildings (Fig. 20). Once again the average roof load was always less than the average ground load.

Ottawa: (A comparison of 5 different roofs in a short winter)

In the Ottawa area observations were carried out on five roofs. From Fig. 5 it can be seen that the two gable roofs had small loads and both exhibited similar load distributions. This was not true for the three flat roofs. On the roof with a parapet, a large snow concentration occurred along the parapets. The snow was fairly evenly distributed on the roofs without a parapet. Snow tended to pile up adjacent to the higher section on the roof with a raised central portion. This roof which was comparatively sheltered (trees) had greater loads than any of the others. In all cases the average roof load was less than the average ground load.

Fort Churchill: (An example of extreme drifting)

Although the ground load in this area was up to 30 psf the roof loads were nearly zero for both a flat and a pitched roof (Fig. 6). Very large loads were measured on the small porch roof attached to the side of the flat-roofed building. Photographs of this accumulation are shown in Figs. 21 and 22. Several features of the local climate prevented large snow accumulations. Wind speeds were high and there were many hours of bright sunshine in spite of the cold weather.

C Stations: R.C.A.F.

On all the large roofs used at these stations, wind action resulted in drifts against the walls of raised sections and on lowered roofs. It should be noted that the average load for the arch hangar was taken from depth measurements on the flat wings at the base of the arch (Fig. 12) and does not represent a true average roof load since the observed area accumulates large local drifts. As expected, high average loads were found on these sections.

General Discussion

From the little information obtained so far, it appears that the assumption of a uniformly distributed snow load is not generally valid. The following remarks are intended as preliminary comment only.

On flat roofs, the average snow load is less than the load near roof projections such as parapets. In many cases therefore, the use of a smaller uniform load over the major part of the roof with a larger, perhaps triangular load beside roof projections would give a more economical and a more accurate design than the present uniform load. On some roofs, the greater accumulation of snow on some portions of the roof results in an unsymmetrical loading pattern which may be critical to the structure, e.g., on arched and pitched roofs where one side often shows much more snow than the other.

An excerpt from a Russian building code (see appendix), gives an example of a specification for unbalanced load. In this case the possibility of stress reversal in truss members due to unbalanced load is covered by a "shape factor" of 1.4 for one side (or for a lowered roof portion) and of 0.6 on the other side of the span (or for a projecting roof portion). Some system of form factors for various roof types should be included in a design snow load specification (as is now done in the NBC for the roof slope only).

To date, the observations of the survey have been made at the majority of stations under below average snowfall conditions. Years of high snowfall may lead to different conclusions because large loads may be distributed differently than small loads. For example, in an exposed location snow drifts on flat roofs would not be higher than the parapets. Thus, in the case of a snowfall deeper than the parapets the load would probably be more nearly uniform. In sheltered locations the snow accumulation is independent of parapets. This factor might be considered in regions of deep snowfall.

Assuming that the past year's records are typical it would seem possible in the future to reduce the basic uniform design snow load. The distribution of snow loads depends, however, not only on the action of the wind (drifting), the temperature (snow creep), and the amount of sunshine but also on the shape of the structure itself. All the factors causing uneven accumulation are highly variable even in one location. Therefore, any coefficient or shape factors based on a number of observations must be carefully interpreted for a design loading pattern. It seems inevitable, therefore, that any new improved code provision for snow loads will be more complicated than are present regulations. It is also possible that reductions made on account of shielding may be questionable because of the possible removal or addition of surrounding objects.

For the past few years meteorological stations across Canada have been recording the depths of snow on the ground. When several more years of records are available, it should be possible to predict the return period of large snow depths more accurately than at present. Before a design load is specified thought should be given to the probability of overload. If one assumes that a design load should be such that it will occur a few times during the life of the structure, the load expected to occur once every ten years might be an appropriate ground load. This period is called the return period. The choice of the return period should actually be based on the expected life of the structure.

When several years of records are available, it should be possible to specify two design features:

(1) What proportion of the specified ground snow load should be used as the basic uniform design load for various climate zones?

(2) What loading patterns should be added to this basic load to account for local drifting and snow sliding? These statements are not possible with any degree of accuracy however, after only one year of complete observations.

Acknowledgments

Without the active participation and assistance of a large number of observers this extensive survey would not have been possible.

The Division of Building Research wishes to express its appreciation to all of these, and in particular to the many building officials and private companies taking B Station observations, to the RCAF personnel at the C Stations and to Messrs. M. Huepeden and J. Stark in Ottawa. Grateful appreciation also goes to A Station observers of the Meteorological Branch of the Department of Transport (Goose Bay and Gander), the Dept. of National Defence (Churchill), the Dept. of Northern Affairs and National Resources (Aklavik), the École Polytechnique at Montreal, Queen's University at Kingston, the University of Toronto, the University of Manitoba at Winnipeg, the University of Alberta at Edmonton and the staff of the Division of Building Research in Halifax, Saskatoon, Glacier, Vancouver and Ottawa.

TABLE I

SNOW LOADS FOR A STATIONS

Station	Roof	N.B.C. (psf)	Max. Av. Ground (psf)	Max. Av. Roof (psf)	Max. Observed Roof (psf)
Aklavik, N.W.T.	Gable: Exposed Heated Insulated	30	25	14	25
	Gable: Sheltered Heated Insulated	30	25	12	16
Glacier, B.C.	Gable: Not heated (Garage) Insulated	Not Specified	108	16	26
	Gable: Not insulated (House) Heated		110	30	50
	Gable: Not insulated (Office) Heated		111	30	36
	Gable: Sheltered Not heated Not insulated		120	82	95
Montreal, P.Q.	Flat: Heated Insulated In lee of higher roofs	50	32	25	87
	Flat: Heated Not insulated	50	32	22	30
	Gable: Heated Insulated		50	9	38
Ottawa, Ont.	Gable: Heated Insulated	45	32	4	7
	Gable: Heated Insulated	45	25	3	7
	Flat (no parapet) Heated Insulated	50	34	14	20
	Flat (parapet) Heated Insulated	50	32	17	32
	Flat (raised section) Insulated Heated	50	32	22	40
Fort Churchill, Man.	Gable: Heated Insulated	55	33	3	6
	Flat: Heated Insulated	55	33	0	30
Gagetown, N.B.	Gable: Heated Insulated	55	25	14	25
	Flat: Heated Insulated	60	24	9	22
Kingston, Ont.	Gable: Heated Insulated	45	21	4	8
	Flat: Heated Insulated	55	12	7	31
Gander, Nfld.	Gable: Not heated Insulated	40	20	2	5
	Flat: Not heated Insulated	45	14	2	2
Halifax, N.S.	Gable: Heated Not insulated	35	13	3	5
	Flat: Heated Insulated	40	12	8	20
	Flat: Heated Insulated	40	8	12	19
Goose Bay, Lab.	Gable: Heated Insulated	75	14	4	4
	Flat: Heated Insulated	90	12	4	6
Winnipeg, Man.	All roofs	35	4	2	2
Toronto, Ont.	All roofs	35	5	5	9
Saskatoon, Sask.	All roofs	35	9	2	5
Vancouver, B.C.	All roofs	30	0	0	0
Edmonton, Alta.	All roofs	25	4	2	2

TABLE II

SNOW LOADS FOR C STATIONS

Station	Supply Depot			Arch Hangar			Mech. Equip. Garage			Cantilever Hangar			NBC
	Max. Ground	Max. Roof	Drift	Max. Ground	Max. Roof	Drift	Max. Ground	Max. Roof	Drift	Max. Ground	Max. Roof	Drift	
Cold Lake	21	12	34	21	13	23	19	4	8	17	9	16	30
Comox	0	0	0	0	0	0	0	0	0	0	0	0	45
Downsview	0	0	0	0	0	0	0	0	0	0	0	0	35
North Bay	20	6	21	14	16	56	16	4	40	-	-	-	55
Winnipeg	4	3	7	4	4	8	5	3	6	5	3	12	35
Lancaster	-	-	-	-	-	-	12	5	12	11	8	21	25
Ottawa	-	-	-	46	18	86	48	8	22	46	7	23	50
Goose Bay	13	0	-	13	0	-	13	-	-	13	0	-	90

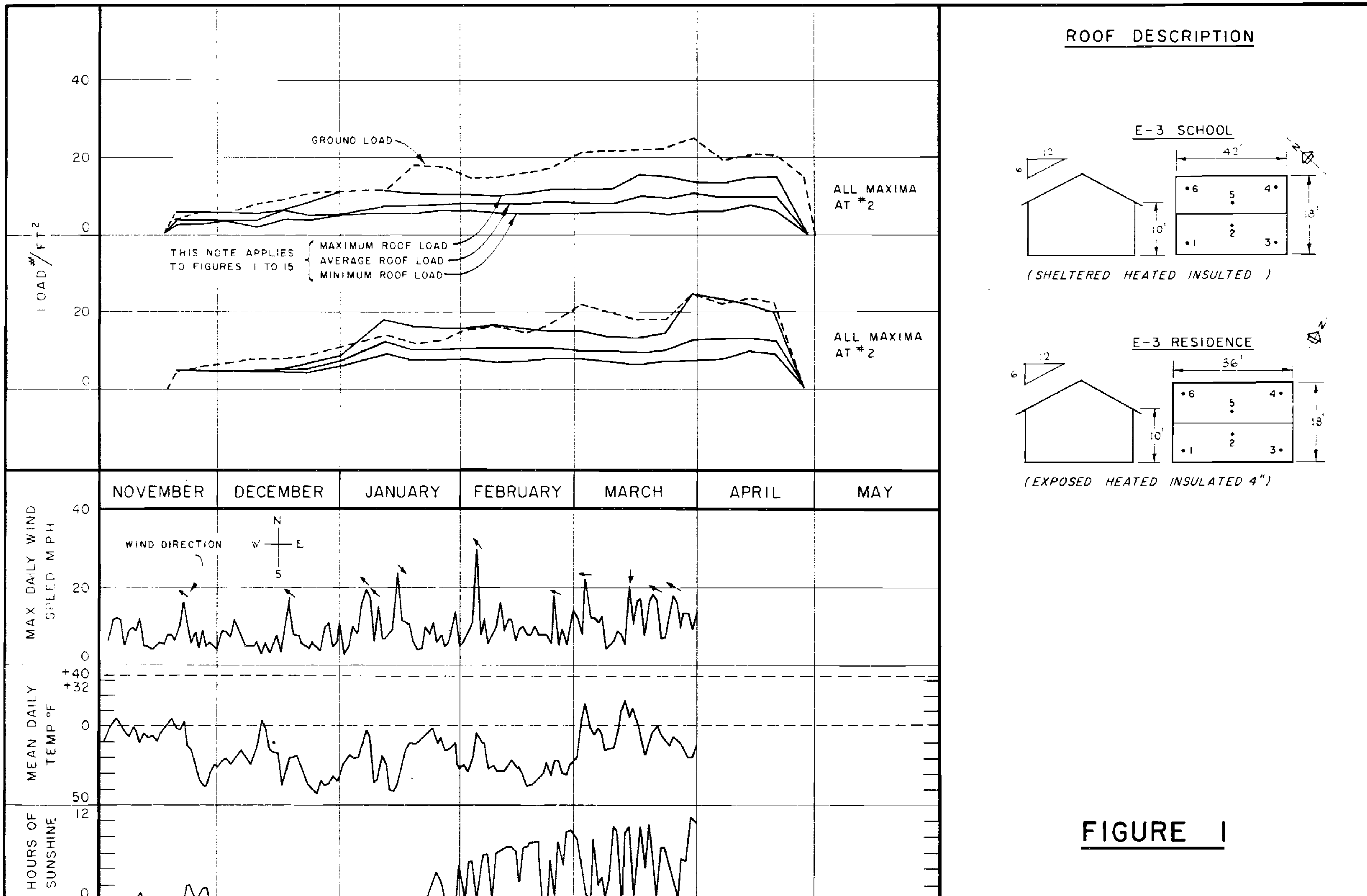
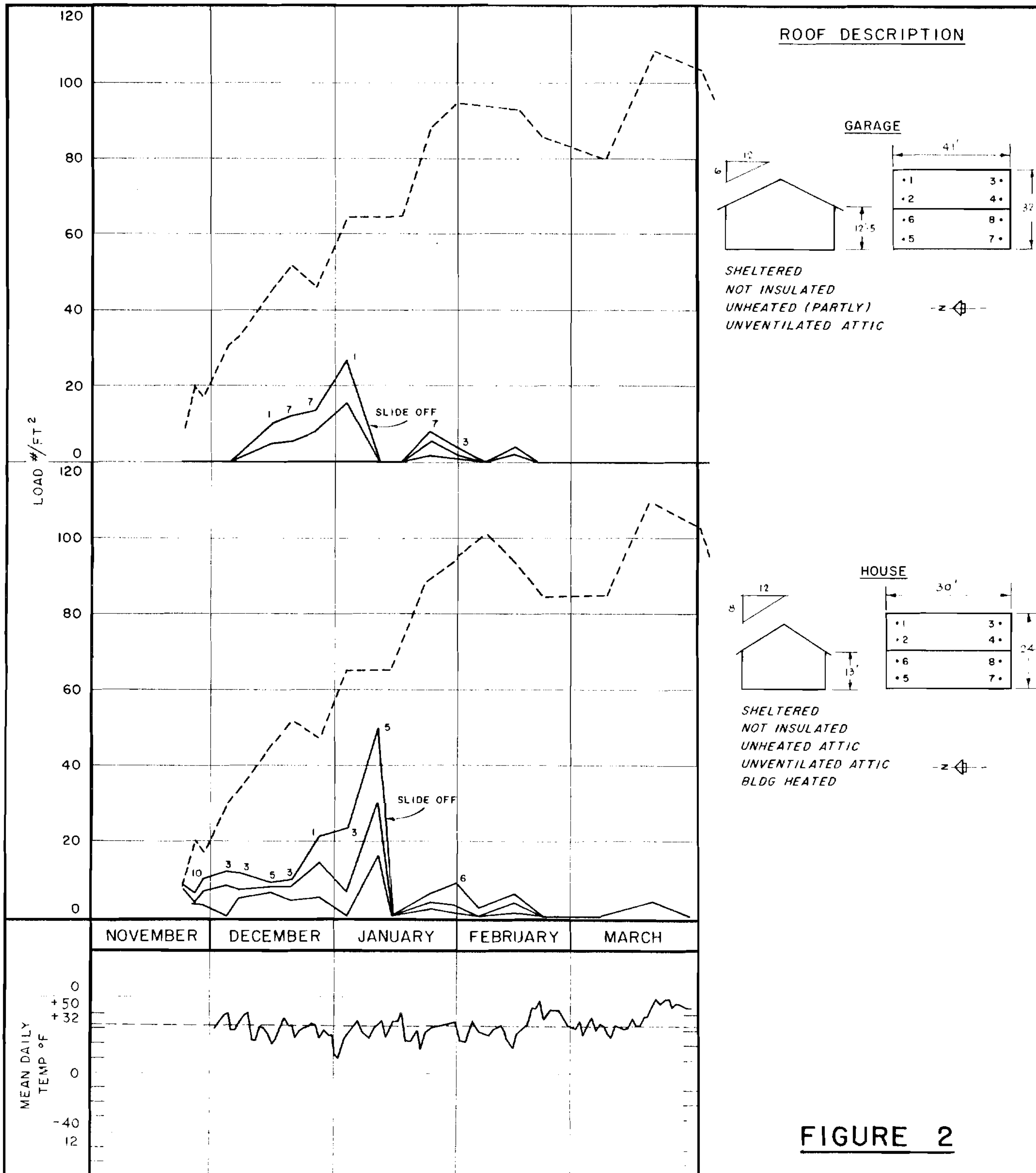


FIGURE 1

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

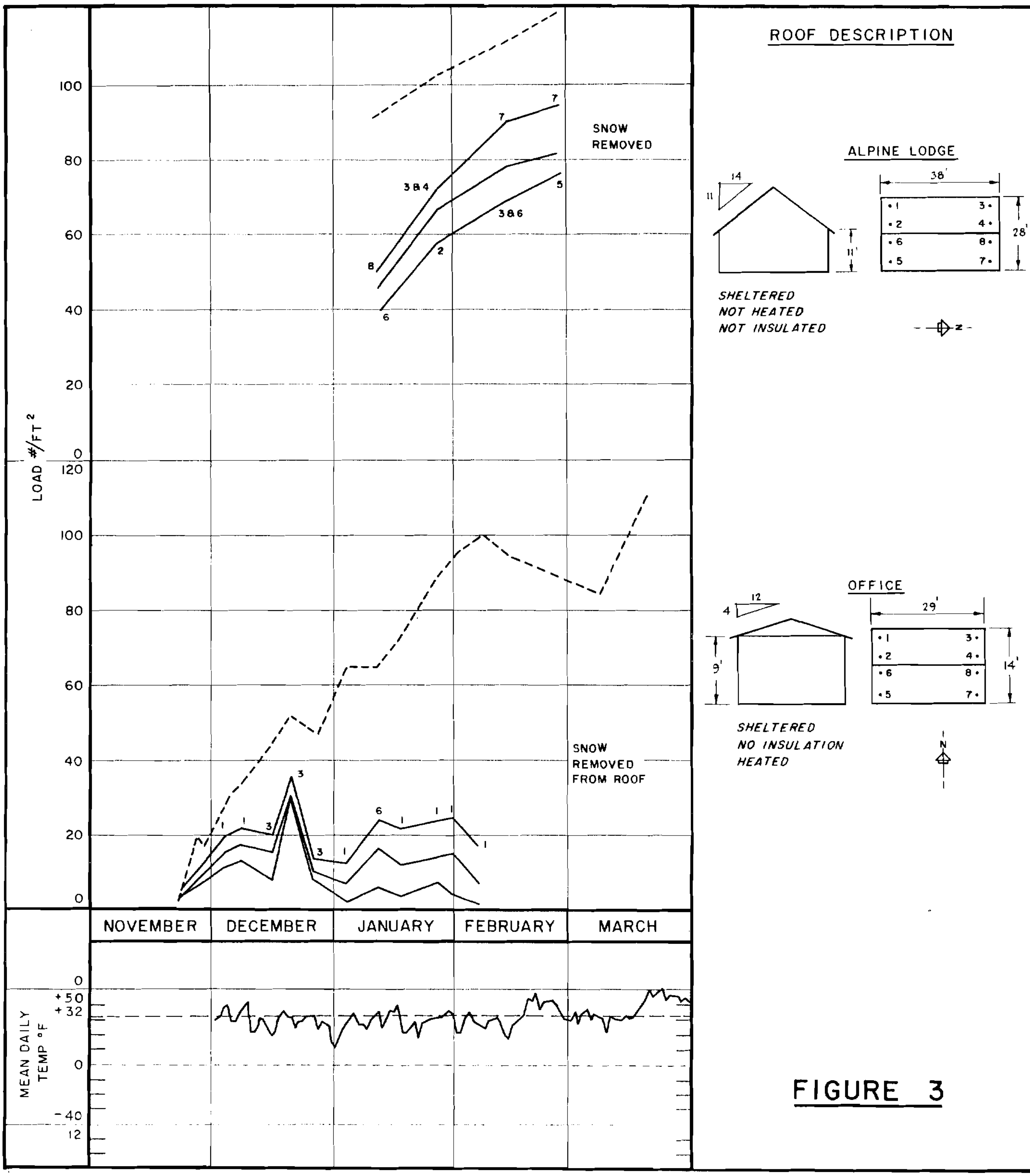
LOCATION: INUVIK, N.W.T.



SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: GLACIER, B.C.



SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: GLACIER, B.C.

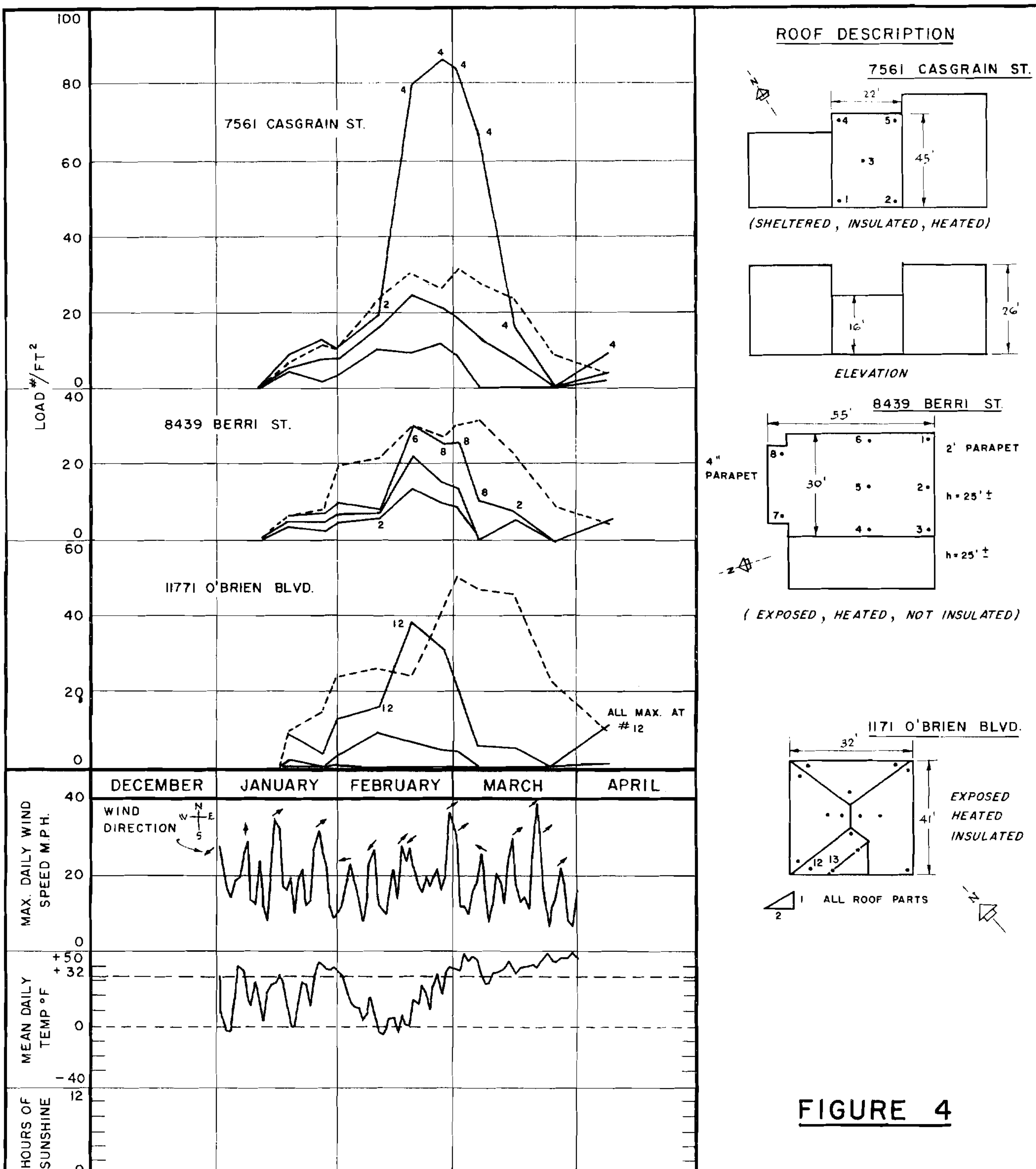


FIGURE 4

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: MONTREAL

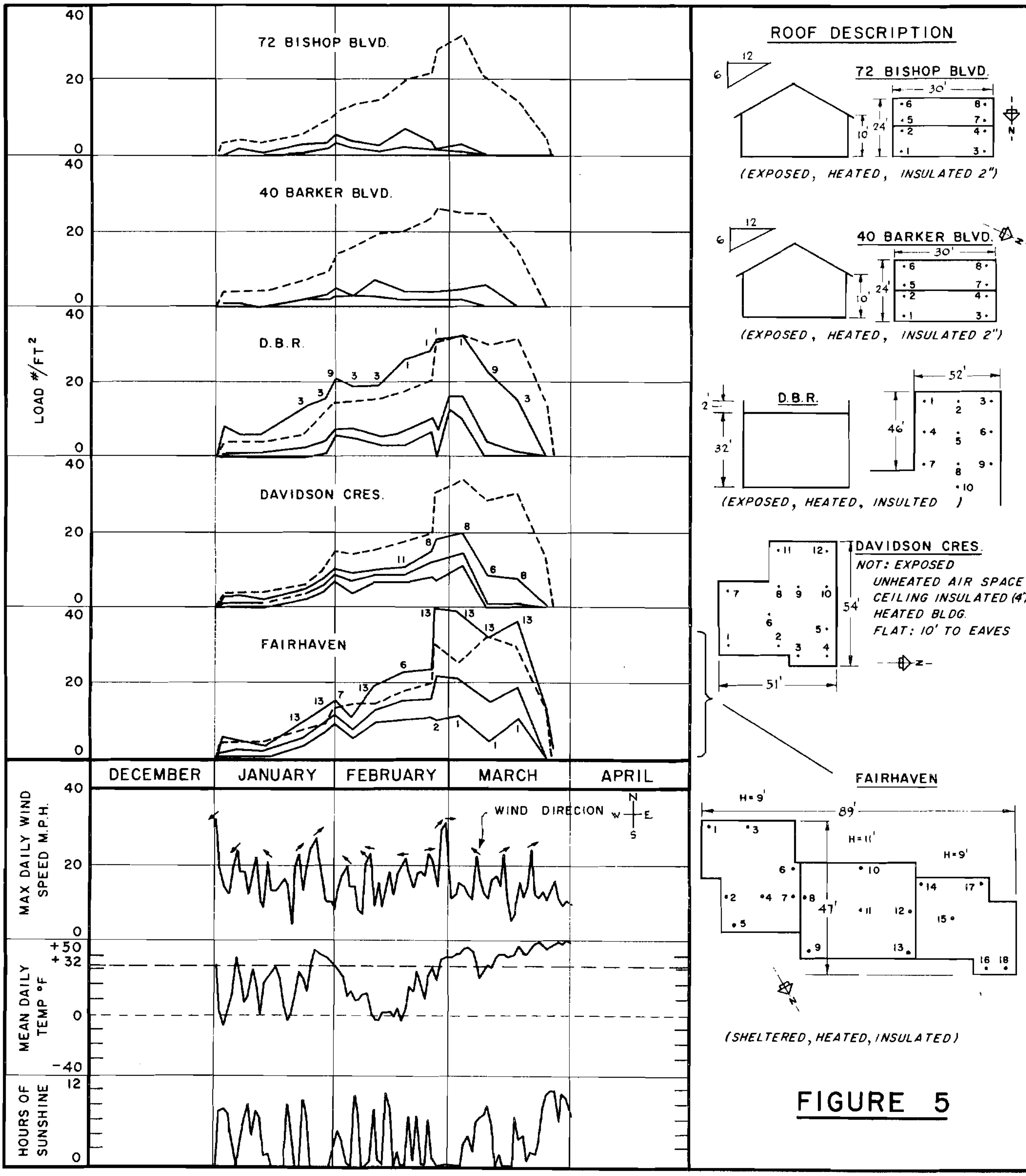
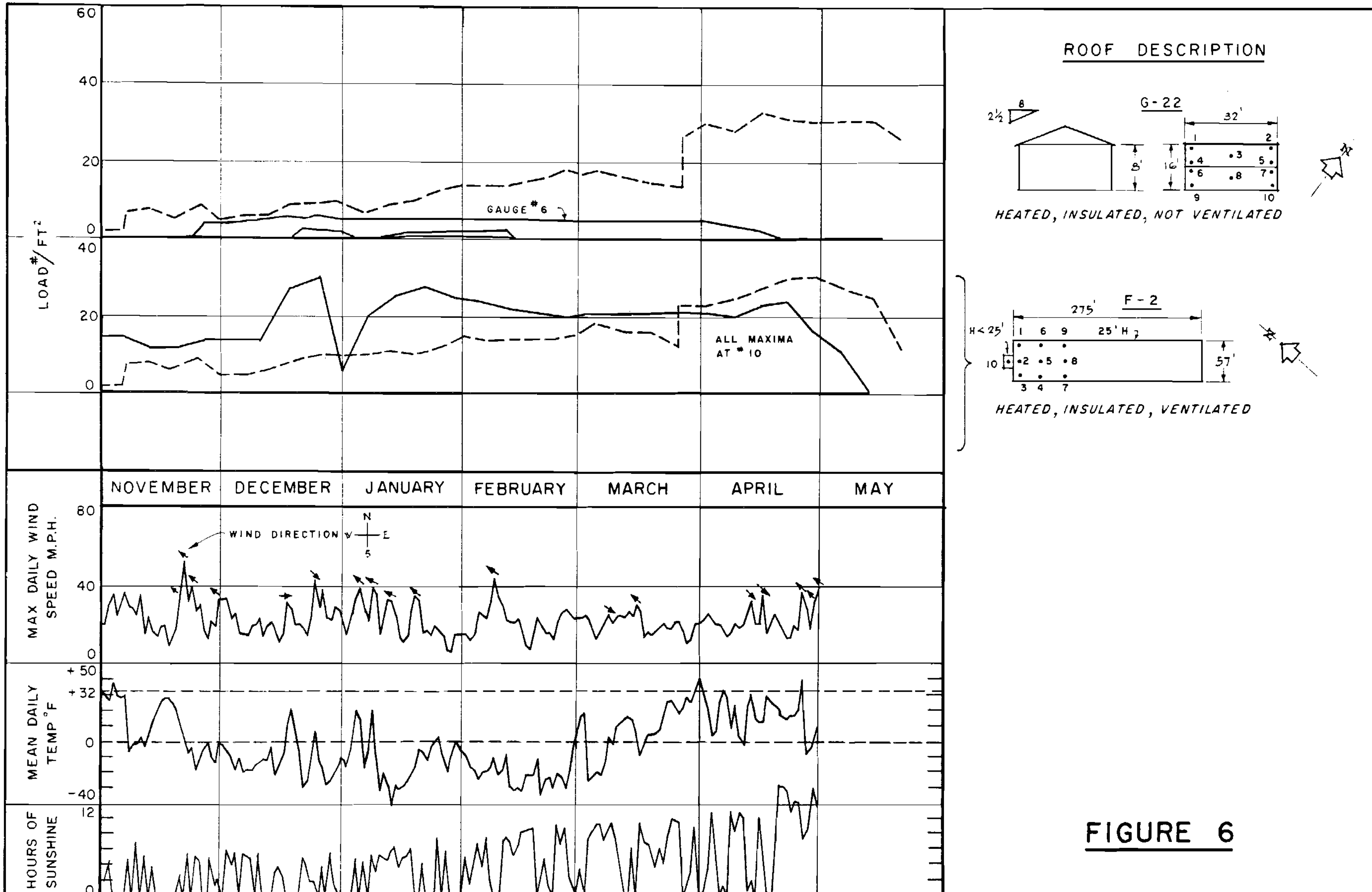


FIGURE 5

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: OTTAWA



SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: FORT CHURCHILL

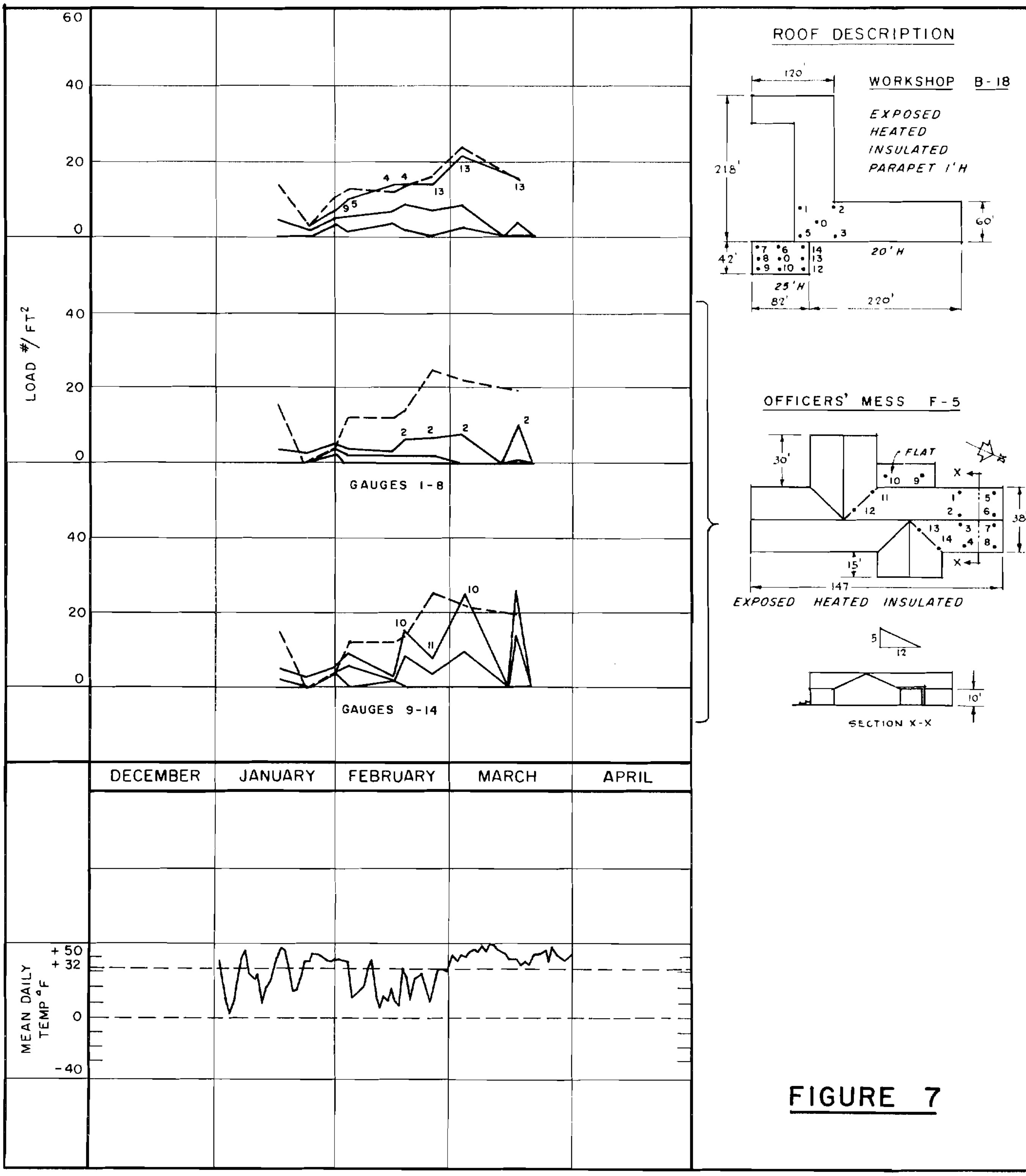


FIGURE 7

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: GAGETOWN, N.B.

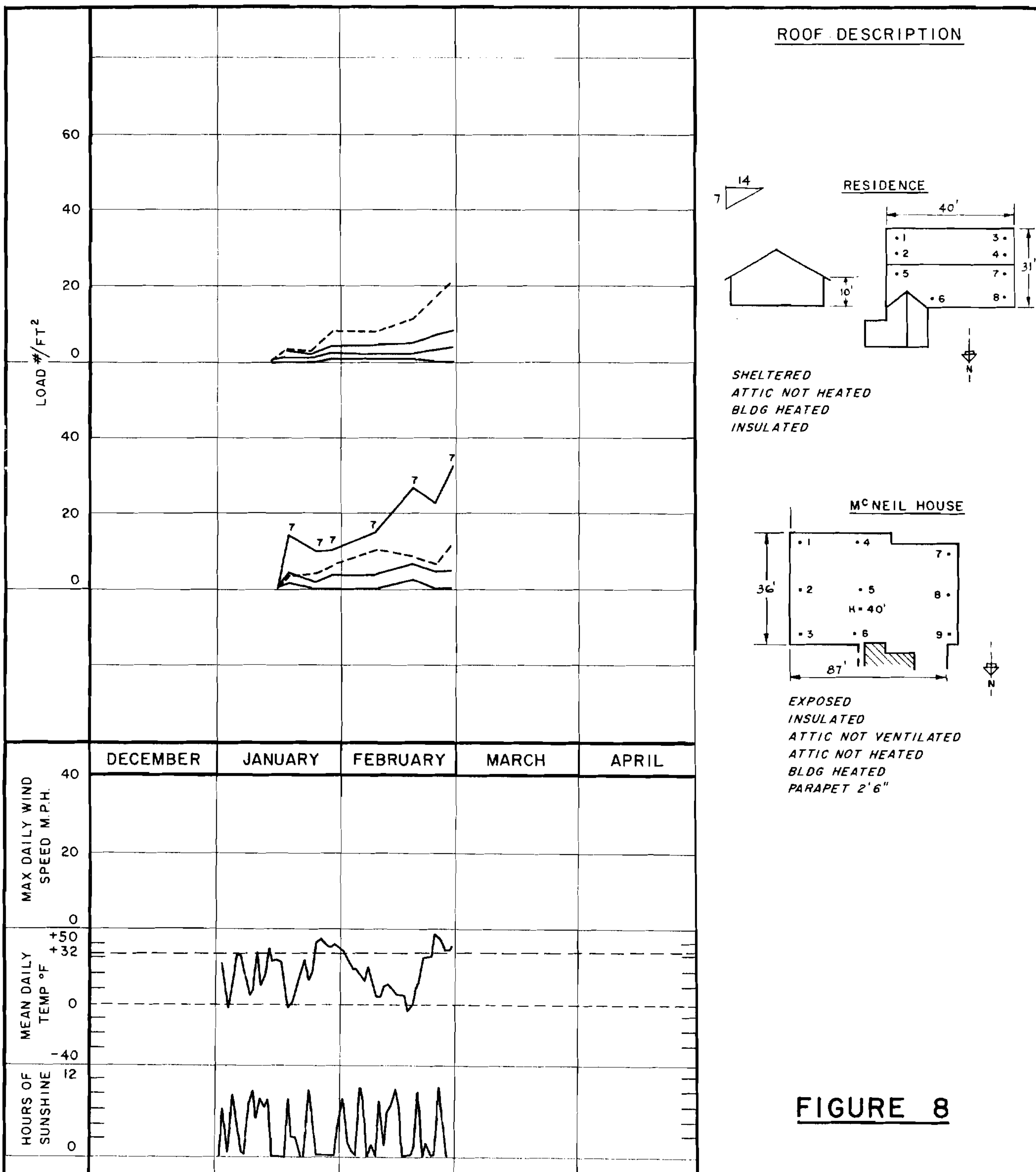


FIGURE 8

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: KINGSTON, ONT.

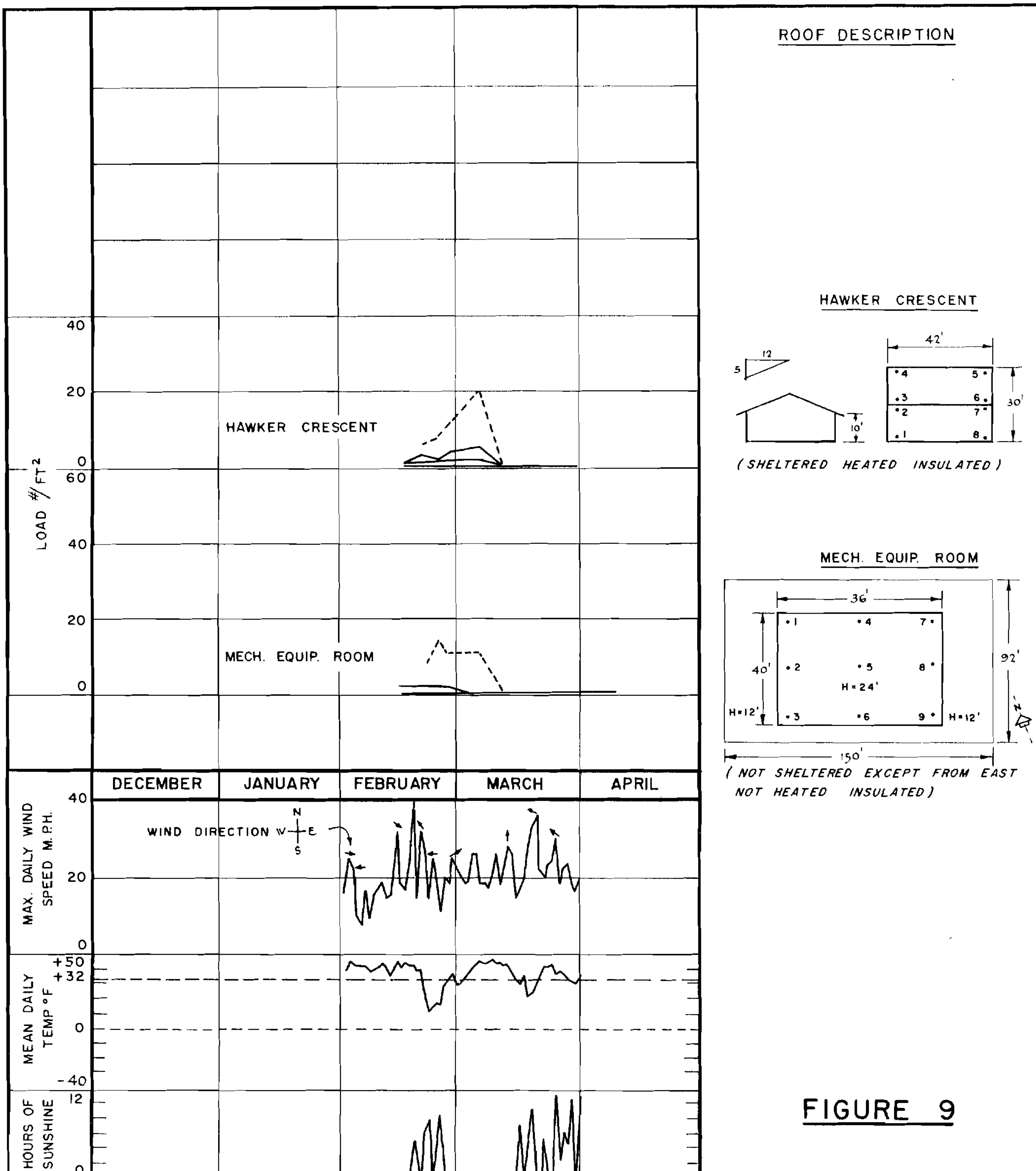


FIGURE 9

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: GANDER

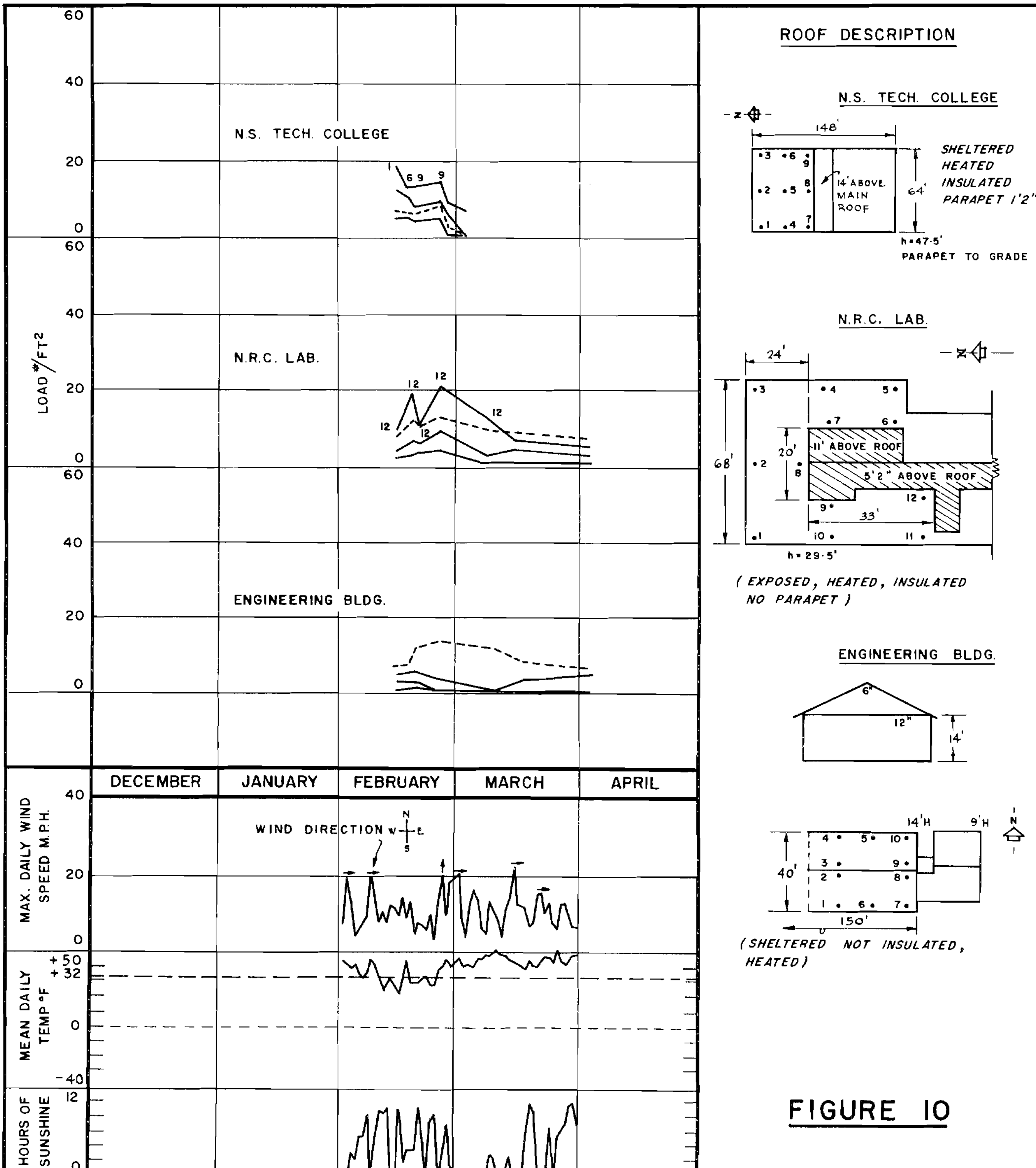


FIGURE 10

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: HALIFAX, N.S.

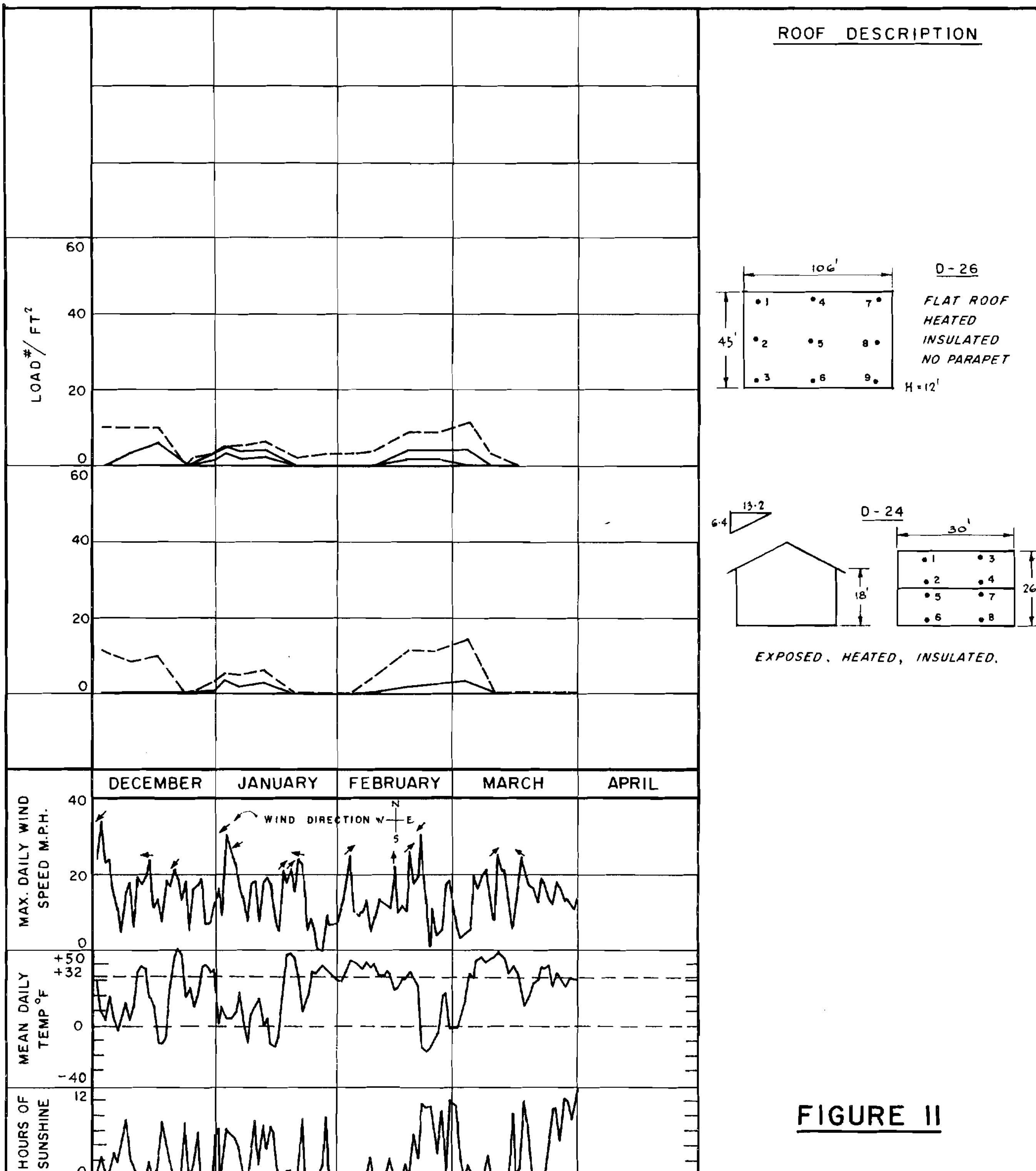
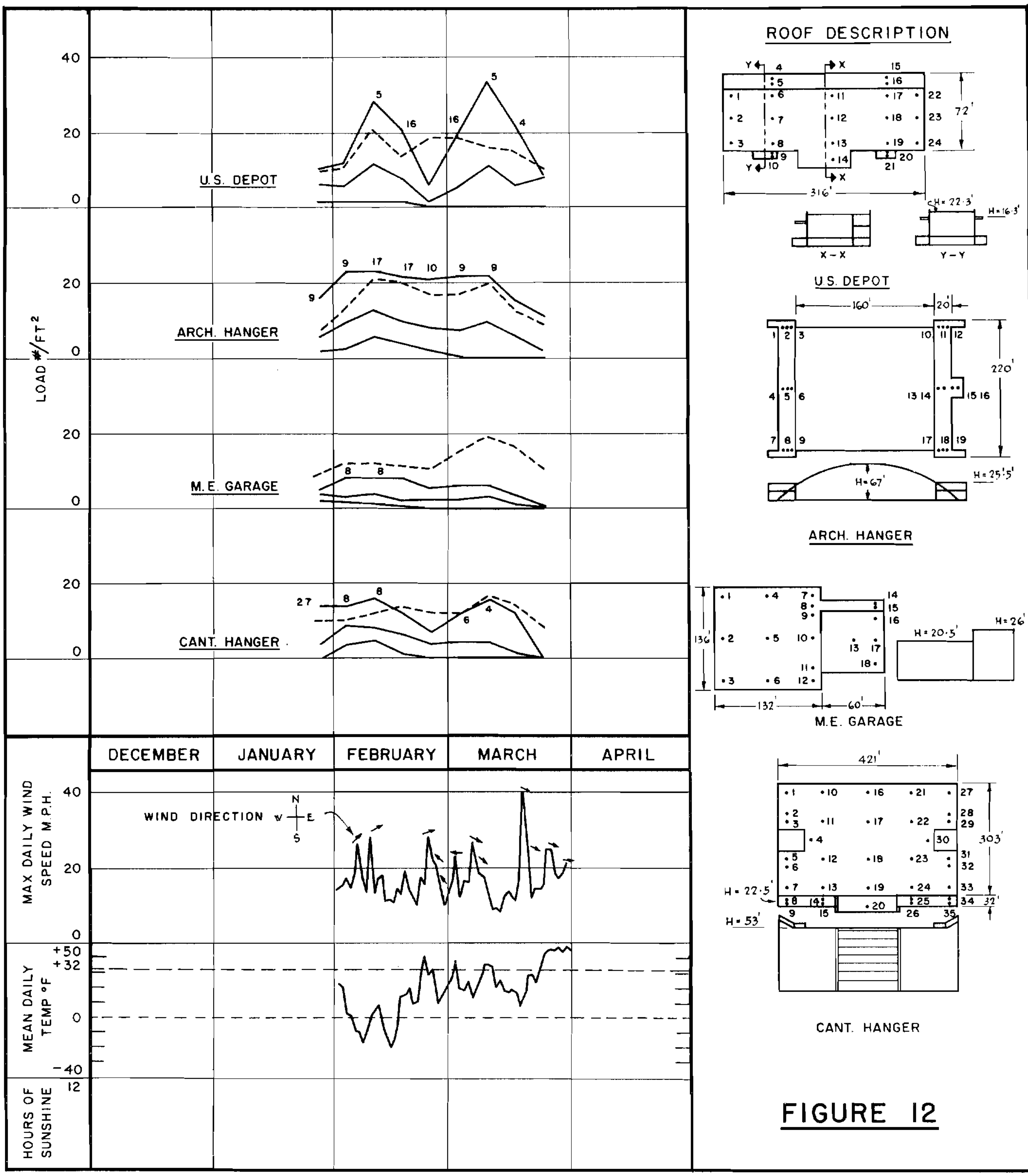


FIGURE II

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

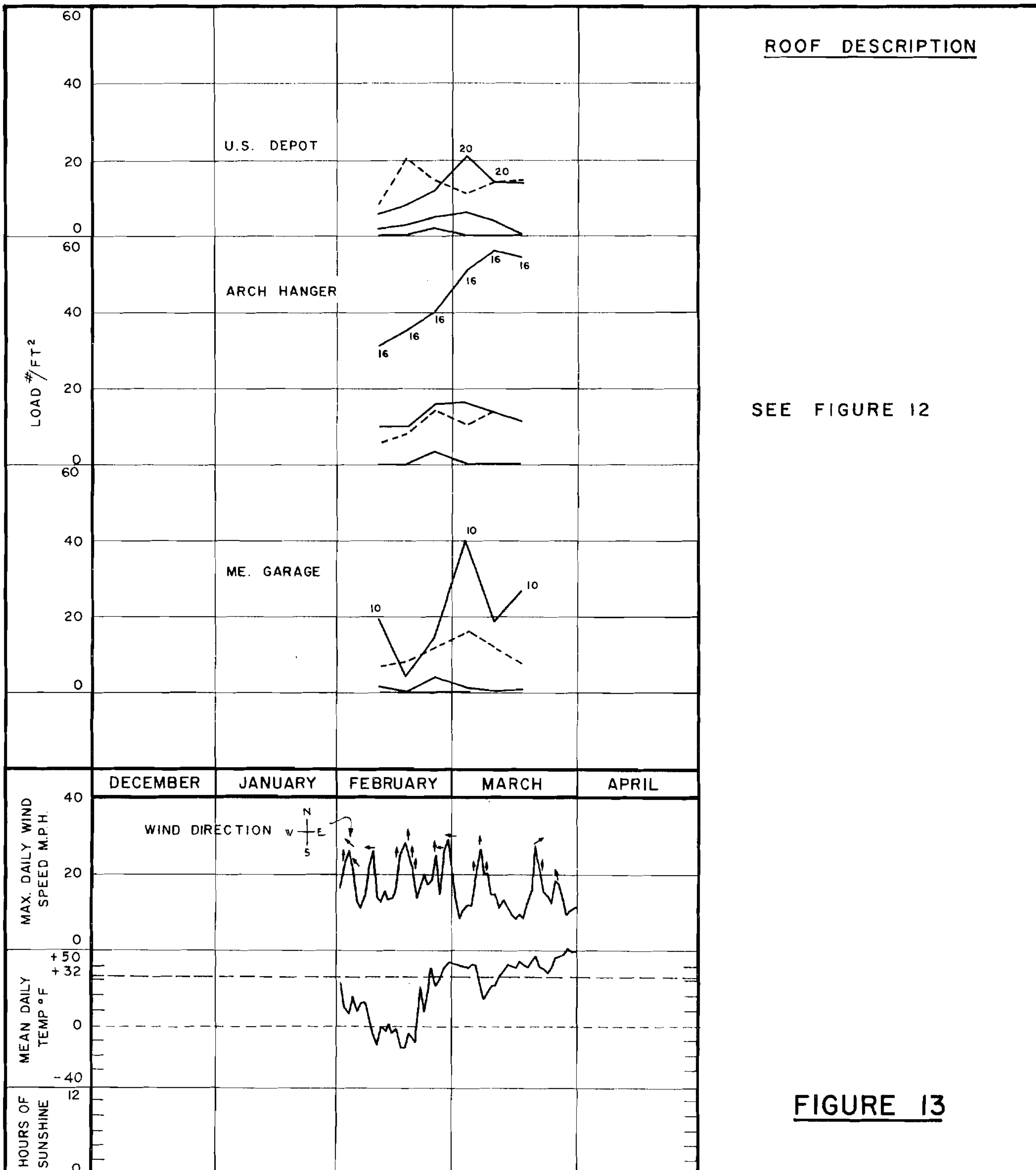
LOCATION: GOOSE BAY



SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: R.C.A.F. STATION COLD LAKE, ALTA.



SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: R.C.A.F. NORTH BAY

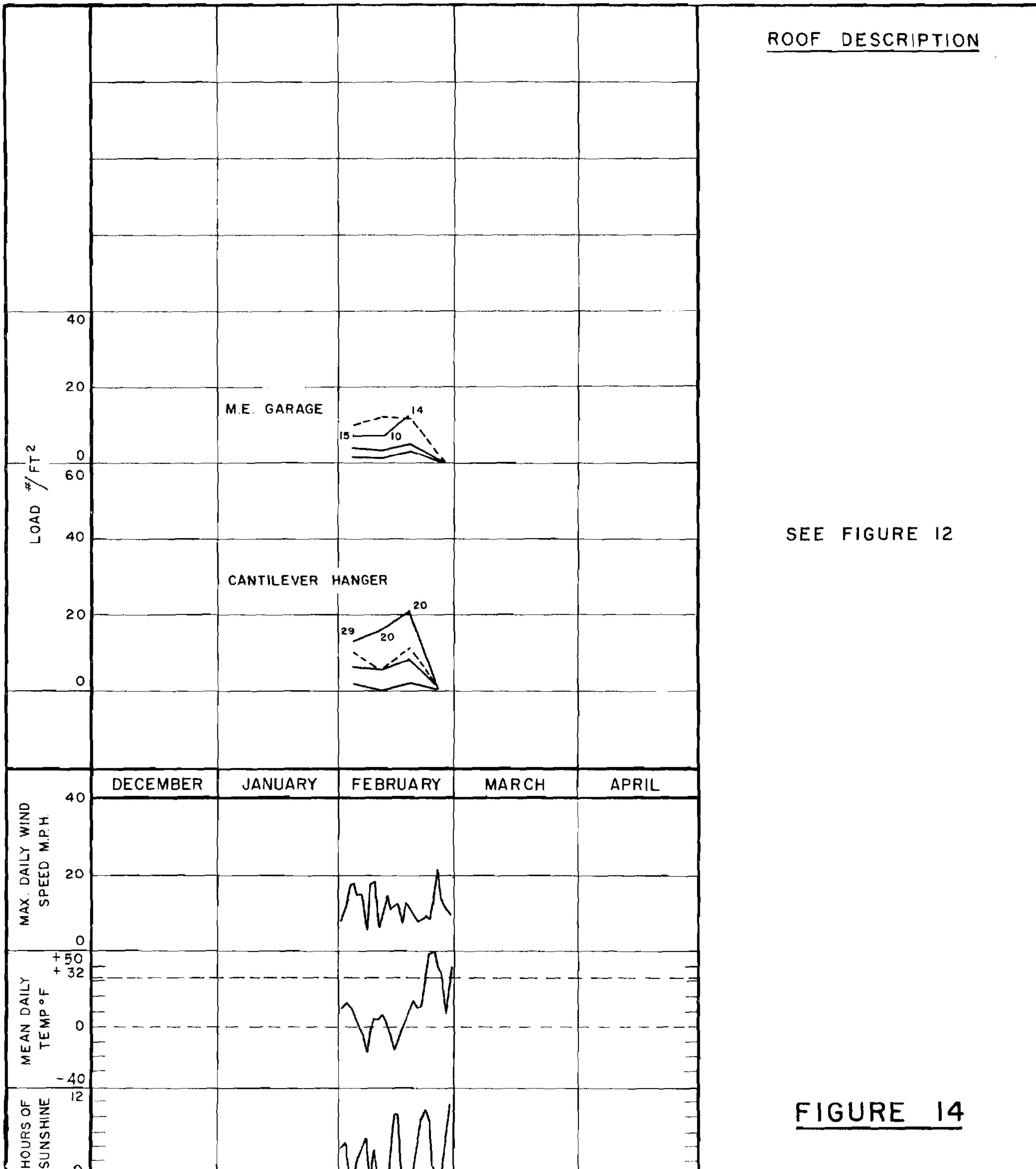
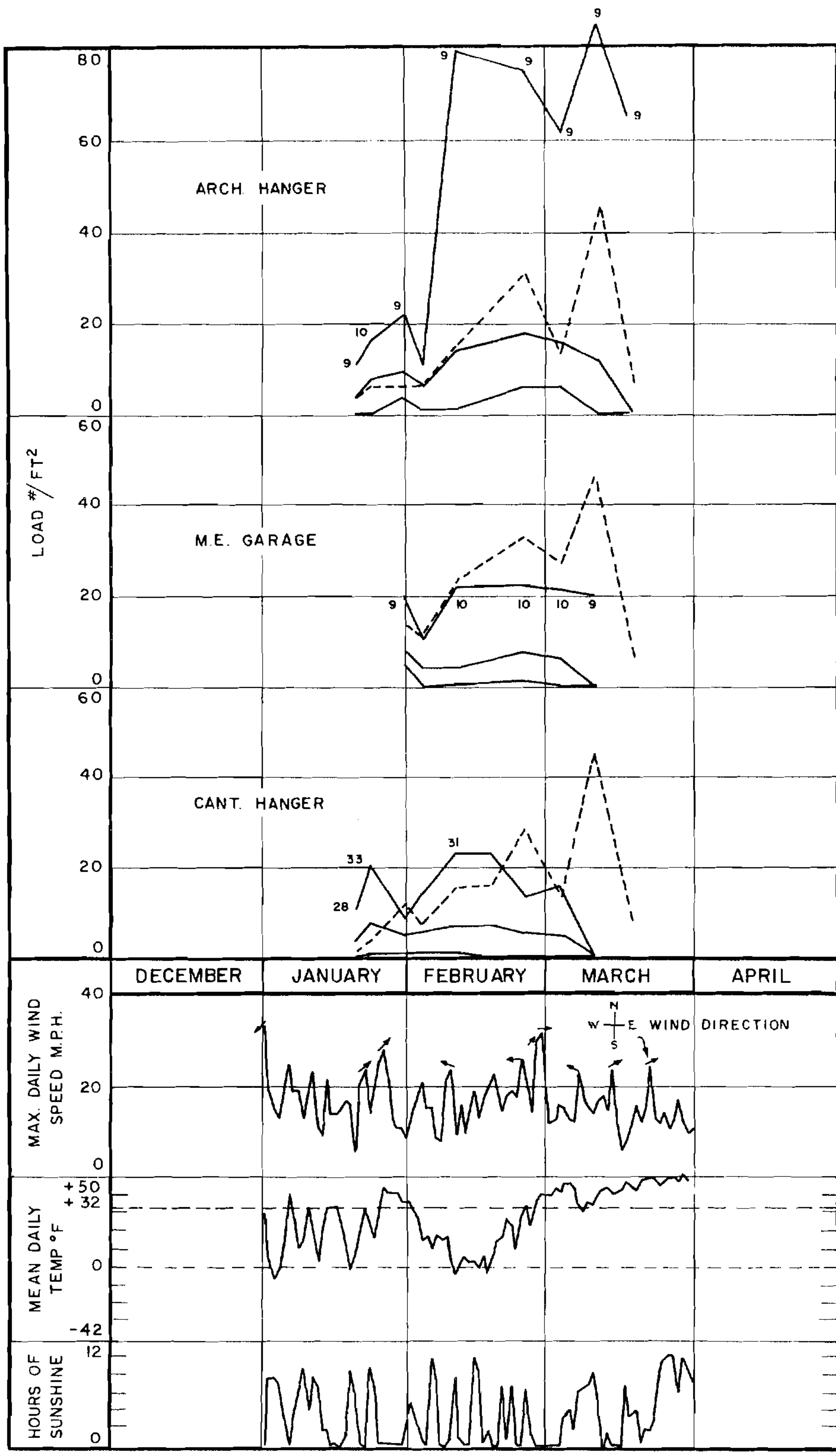


FIGURE 14

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

LOCATION: R.C.A.F. LANCASTER, ALTA.



ROOF DESCRIPTION

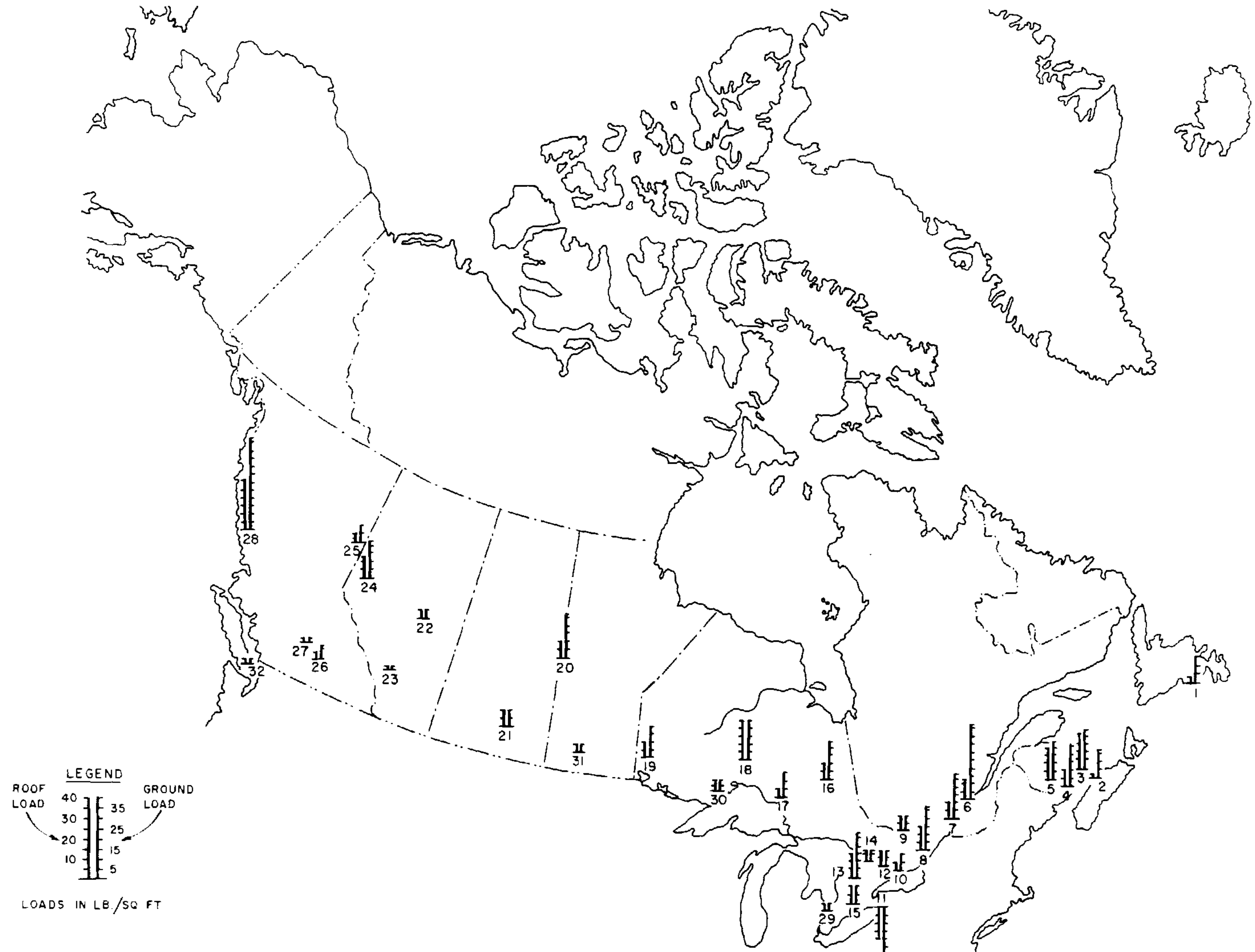
SEE FIGURE 12

FIGURE 15

SNOW LOAD OBSERVATIONS ON ROOFS

YEAR: 1957/58

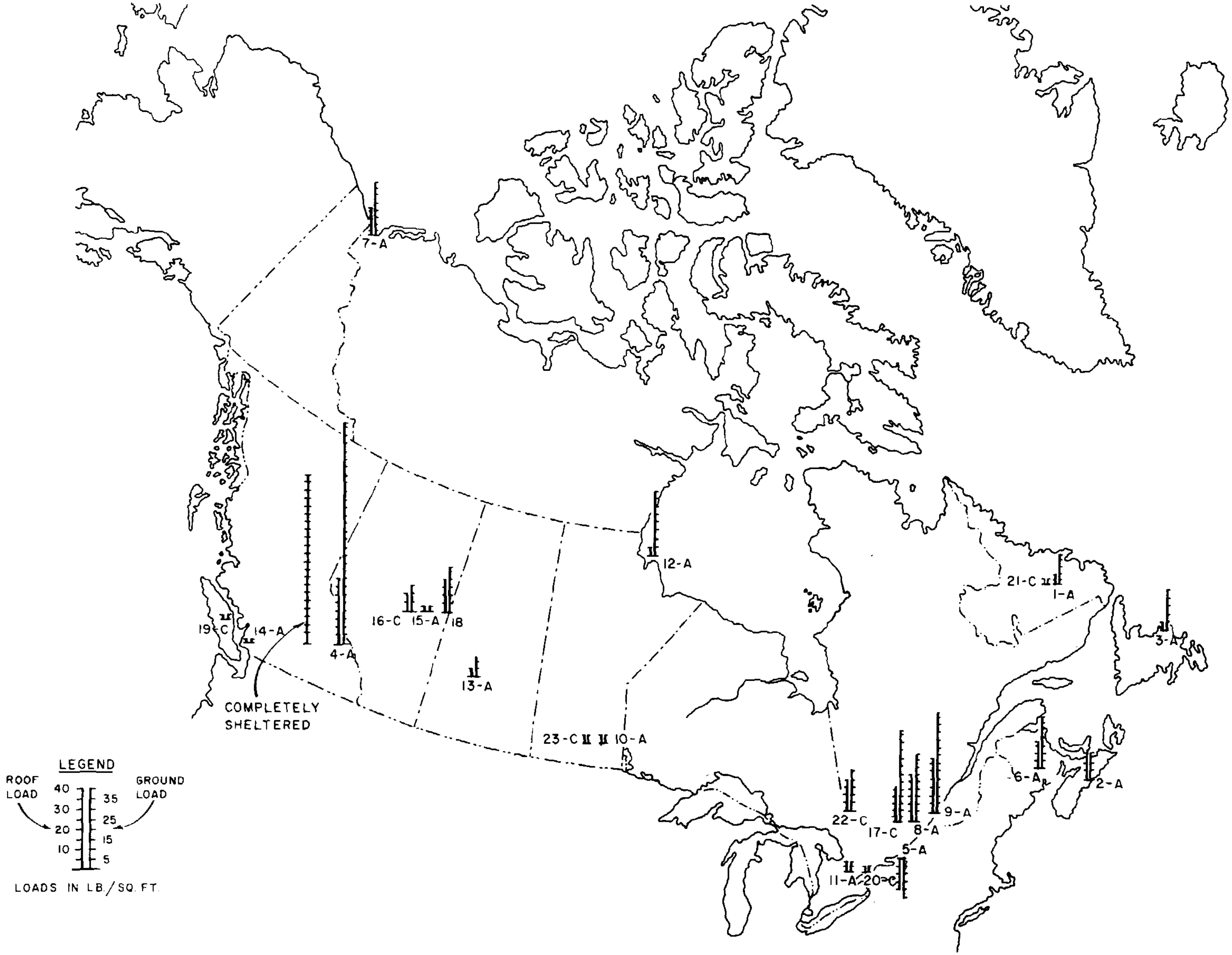
LOCATION: R.C.A.F. OTTAWA



No	B STATIONS
1	GRAND BANK
2	AMHERST
3	MONCTON
4	SAINT JOHN
5	FREDERICTION
6	TROIS RIVERS
7	LACHINE
8	PERTH
9	PERTH
10	BELLEVILLE
11	FORT ERIE
12	PETERBOROUGH
13	BARRIE
14	ORILLIA
15	LONDON
16	TIMMINS
17	WAWA
18	GERALDTON
19	KENORA
20	THE PAS
21	REGINA
22	JASPER PLACE
23	CALGARY
24	GRAND PRAIRIE
25	DAWSON CREEK
26	VERNON
27	KAMLOOPS
28	KITIMAT
29	SARNIA
30	PORT ARTHUR AND FORT WILLIAM
31	BRANDON
32	VICTORIA

FIGURE 16 SNOW LOAD SURVEY 1957-58

MAXIMUM ROOF AND GROUND LOADS FOR B STATIONS



No	A STATIONS
1	GOOSE BAY
2	HALIFAX
3	GANDER
4	GLACIER
5	KINGSTON
6	GAGETOWN
7	AKLAVIK
8	OTTAWA
9	MONTREAL
10	WINNIPEG
11	TORONTO
12	CHURCHILL
13	SASKATOON
14	VANCOUVER
15	EDMONTON

No	C STATIONS
16	LANCASTER PARK
17	OTTAWA
18	COLD LAKE
19	COMOX B.C.
20	DOWNSVIEW
21	GOOSE BAY
22	NORTH BAY
23	WINNIPEG

FIGURE 17 SNOW LOAD SURVEY 1957-58

MAXIMUM ROOF AND GROUND LOADS FOR A & C STATIONS

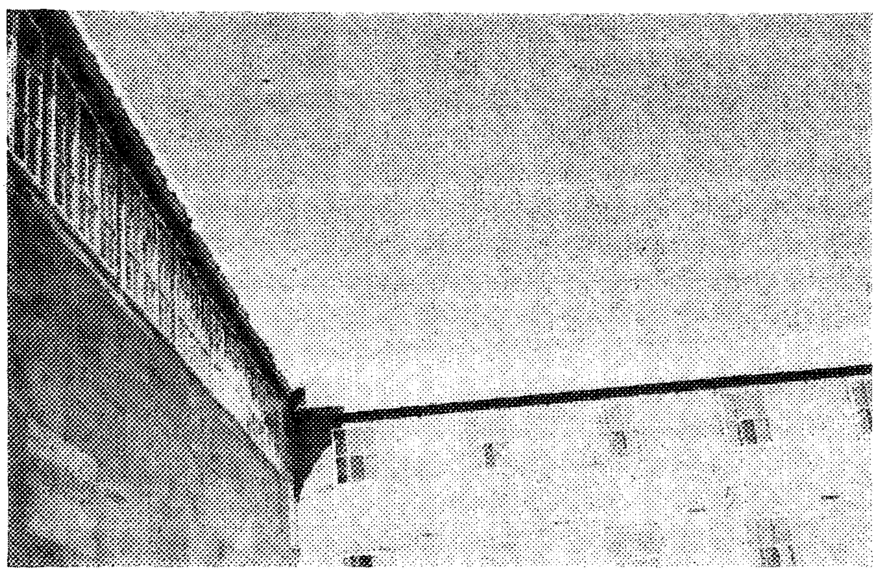
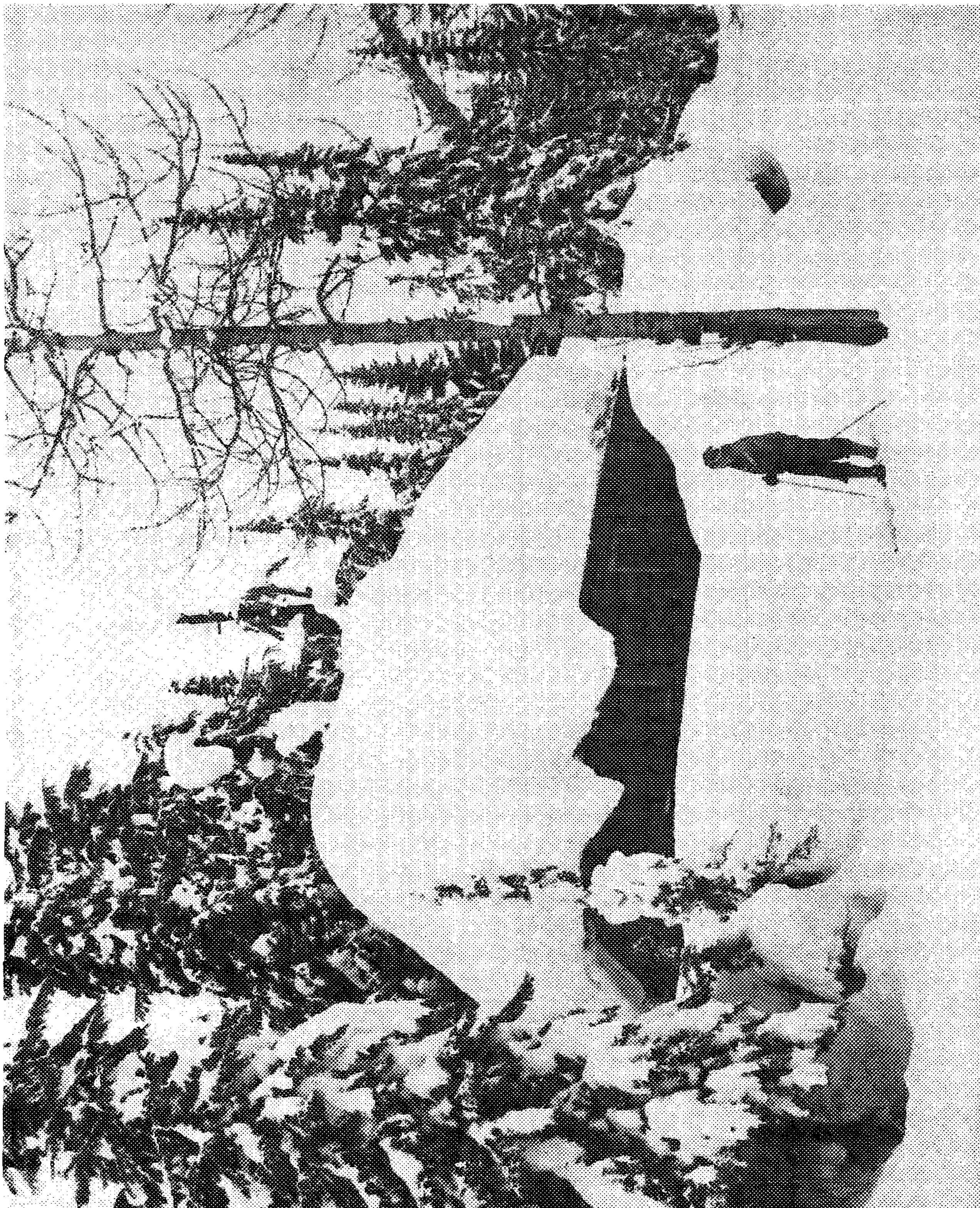
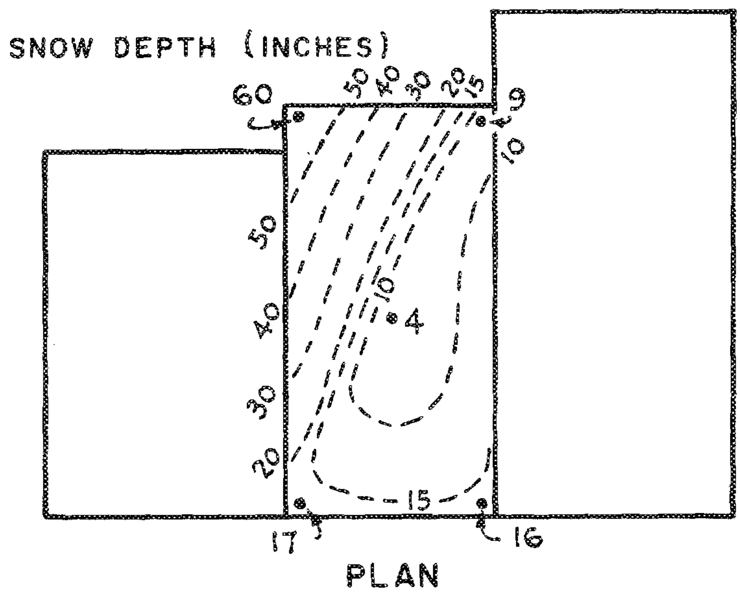


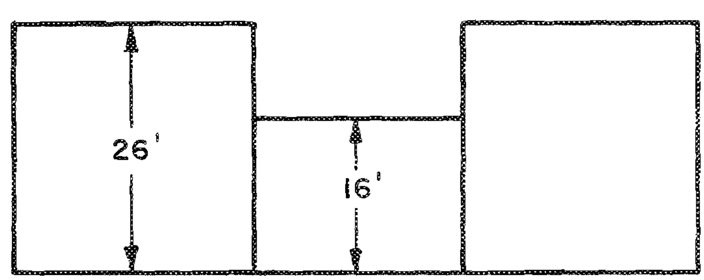
Figure 18. Aklavik (March 30, 1958). E-3 Hostel. Load distribution on a large roof.



(Photo by B. Engler, Banff)

Figure 19. Glacier, B.C. (February 1958). Alpine Club Lodge - Snow accumulation in a completely sheltered area.





ELEVATION
SCALE: 1" = 20'

FIGURE 20

SNOW DISTRIBUTION ON A FLAT ROOF AT MONTREAL, P.Q.

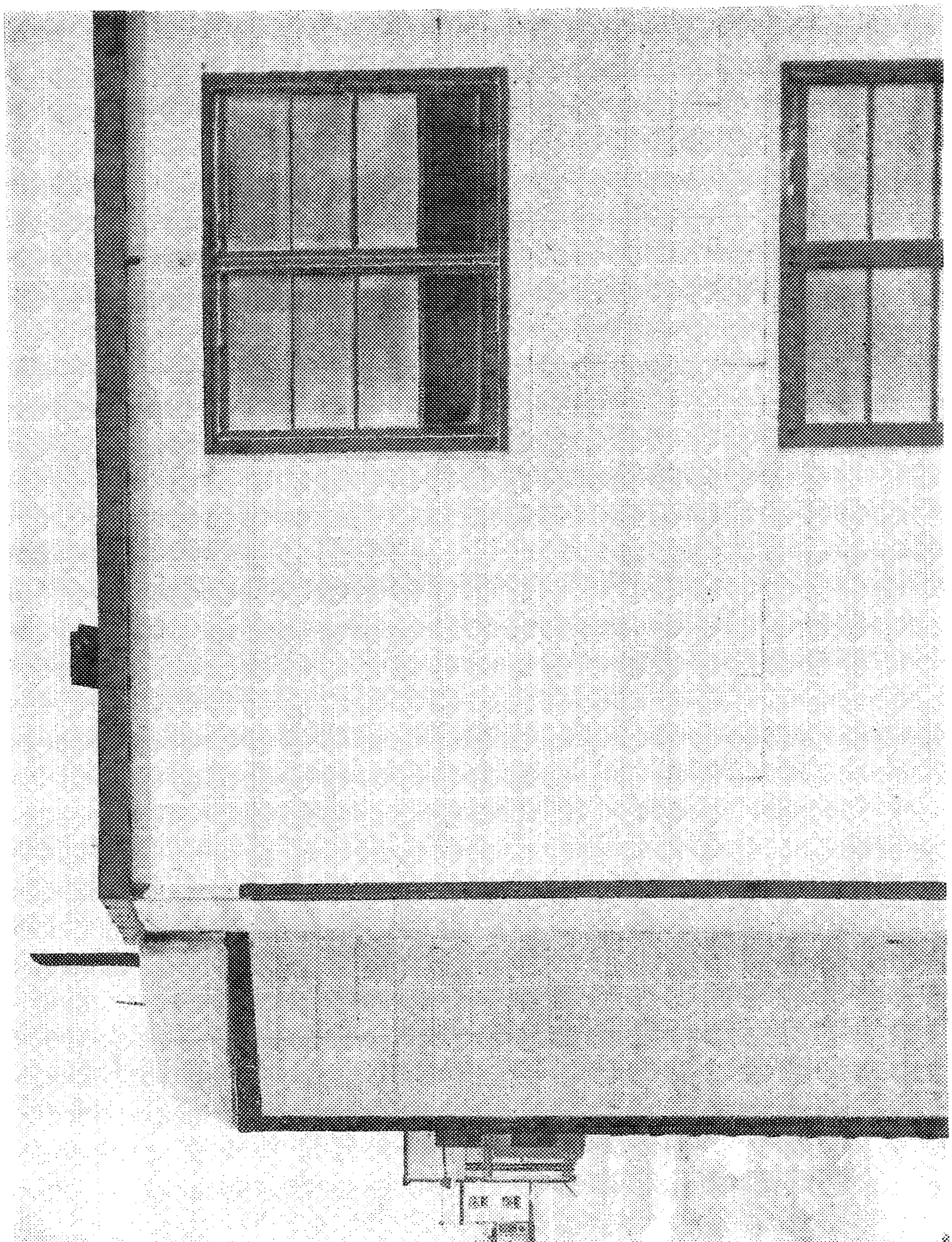


Figure 21. Churchill, Man. (January 13, 1958). Building F-2. Snow accumulation on lowered roof section (main roof is bare).

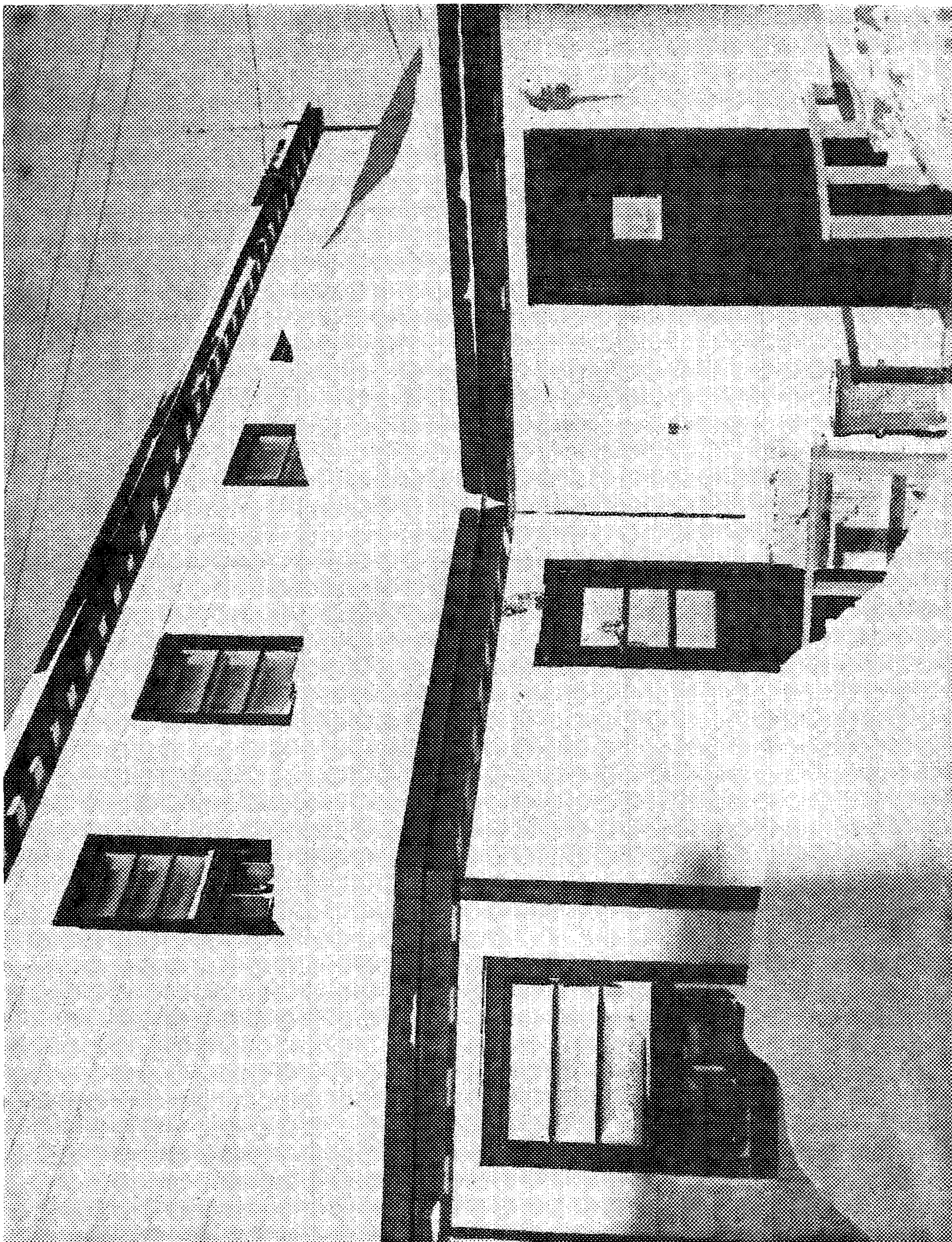
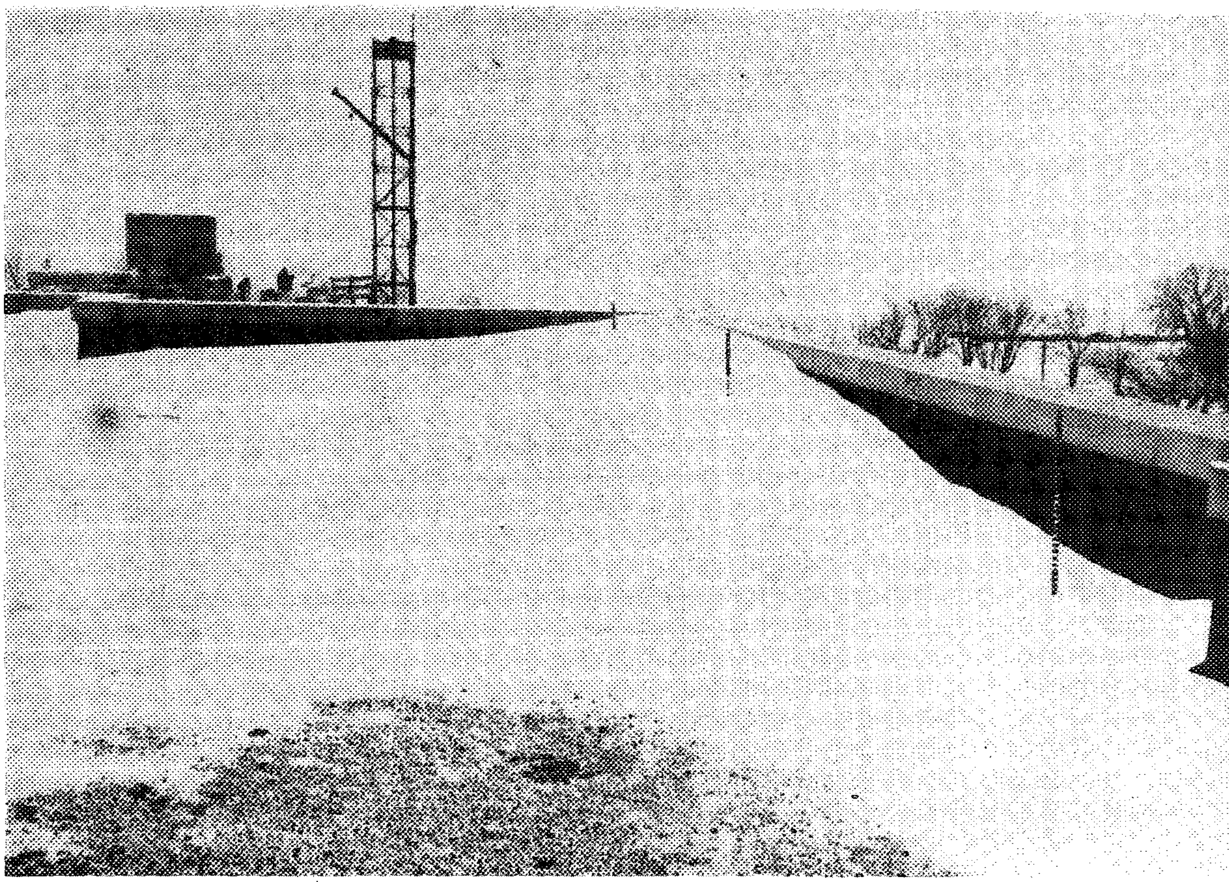


Figure 22. Churchill, Man. (January 13, 1958) Building J-85, looking NE. Snow accumulation on lower roof (main roof is bare).



(Photo by W.R. Berry,
Kingston)

Figure 23. McNeill House, Queen's University, Kingston (February 1958). Snow accumulation at a parapet.

APPENDIX

SNOW LOAD SPECIFICATIONS IN RUSSIA

Specified snow loads in most countries are given as a uniformly distributed load. Some countries stipulate in addition that concentrations due to the shape of the building and the effect of the wind shall be considered but do not state how large these concentrations are. The Russian building code "Construction Standards and Regulations" (1954), however, gives quantitative non-uniformly distributed snow loads. It should be noted that those parts of the USSR for which non-uniform snow loads are specified, have a dry, cold climate in which drifts occur extensively. These might be compared to the Canadian prairies and locations such as Fort Churchill, Manitoba where snow on a roof usually accumulates only along vertical obstructions.

To illustrate the Russian approach to snow loads, the pertinent section from the Russian "Construction Standards and Regulations" and two abstracts of articles which appeared in the Russian periodical "Construction Industry" and which discuss the standards mentioned above are given in this appendix as translated by the author with the help of Mr. G.G. Belkov of the NRC Translations Office. It is hoped to publish the full translations later in a separate report.

1. Russian "Construction Standards and Regulations".

Part II. Section B - Standards for the Design of Load-Bearing Constructions. Section on Snow Loads (p. 46-48) (A.1).

"The snow load per square meter area of horizontal projection of roof is determined according to the formula

$$P_c = pc \qquad (1.4)$$

where p = weight of snow cover in kg/m^2 depending on the region of the USSR according to Table 4

c = coefficient depending on the profile of the roof according to Table 5.

The coefficient of overload "n" for snow load shall be taken equal to 1.4.

The Weight of Snow Cover P

Table 4

No.	Region of USSR (see Fig. A-1)	Weight of Snow Cover in kg/m^2	in psf
1	I	50	(10)
2	II	70	(14)
3	III	100	(20)
4	IV	150	(31)
5	V	200	(41)

Note: In mountain districts, as well as in the regions of extreme north and remote east the weight of snow cover p in kg/m^2 shall be taken numerically equal to 2h, where h = depth of snow cover in cm taken from meteorological observations as the mean of the maximum yearly at a protected place over 10 years. In the mountain districts the weight of snow cover shall be taken not less than 60 kg/m^2 (12 psf)."

Value of Coefficient c

Table 5

No.	Shape of Roof	c	Note
1	Simple roof, pentroof and gable roof slope $\alpha \leq 25°$ $\alpha \geq 60°$	1.0 0.0	At intermediate angles of roof pitch the coefficient c is found by interpolation
2	Simple arched roof	$\ell/10f$	where ℓ = span of arch f = rise of arch The coefficient c shall not be greater than 1.0 nor less than 0.3
3	Complex roof with transversal or longitudinal clerestoreys, with unequal heights of separate parts, etc.	In accord with Fig. A-2	The difference in height H is given in metres

2. The Problem of Snow Load Specification by E.D. Kan Khut (Abstract from "Construction Industry", No. 12, 1954, pages 22-23) (A.2)

In regions of the USSR where there are high winds (e.g. Kazakstan) snow does not accumulate on flat roofs but rather as large drifts behind roof projections. The present standards on snow loads do not take these local climatic features into account.

(a) Figure A-3 illustrates the difference between specified and actual snow load (taken in the Karaganda province). The specified load for flat roofs is 70 kg/m^2 (14 psf).

Snow is not retained on flat roofs, even when there is snowfall without wind the loads on flat roofs never approach those specified. For this location, only once in 8 years did the monthly snowfall exceed 10 cm (4 in.) which with a density of 0.2 for loose snow gives a load of 20 kg/m^2 (4 psf). Since there are no long periods without high winds in the Karaganda a maximum load of 20 kg/m^2 (4 psf) can be used for low-pitched roofs up to 10° slope.

(b) On roof surfaces near roof projections the specified load is 112 kg/m^2 (23 psf) which with an overload coefficient of 1.4 becomes 157 kg/m^2 (32 psf).

The actual snow load depends first of all on the projection height H. Up to certain values of H (which will differ for different localities), a maximum height of 0.9H for snow drift and an average of 0.7H are found (Fig. A-3). The measured specific gravity of drifted snow behind roof projections reaches 0.350. For example, taking a projection height H = 2.0 m, which is not very large, an actual load of $0.7 \times 2.0 \times 350 = 490$ kg/m^2 (100 psf) is reached, about three times the specified load.

Periodic snow removal cannot be considered reliable since snow cannot be removed during blizzards with high wind speeds.

(c) On inclined roofs the specified snow load decreases from 70 kg/m^2 (14 psf) to zero between 25° and 60°.

Actually on the leeward side of roofs with a slope of 35° to 45° snow accumulations up to 1.0 metre have been observed (Fig. A-4), a load reaching 350 kg/m^2 (72 psf).

The difference between the specified and actual snow loads in windy regions occurs because the specified loads are based on the amount of snowfall only, whereas the distribution of snow is also a function of wind speeds. The specified load is the same for Minsk and Karaganda, but the distribution of snow at Karaganda, where there are high winds differs widely from Minsk.

The following errors in the specified loads are therefore apparent:

(1) All roofs with a slope less than 10° and without projections have specified loads which are too large and never encountered in practice. A reduction would provide a great economical saving.

(2) All roofs with steep slopes or projections have much greater actual snow loads than those specified causing damage and even collapse in some cases.

It is desirable that the specification committee organizes field observation and derives snow load specifications which take account of actual accumulation in relation to the wind velocity.

3. Snow Loads According to "Construction Standards and Regulations" by I.I. Gol'denblat, B.G. Korenev and A.M. Sizov, Central Research Institute of Industrial Construction. (Abstract from "Construction Industry", No. 6, 1956, pages 25-27) (A-3)

The Research Institute of Industrial Construction has examined both the distribution and magnitude of snow loads in all parts of the USSR and the influence of snow loads on structural damages and failures after heavy snowfalls.

The magnitude of design roof snow load depends on the amount of snow precipitation (meteorological records), size and shape of roof and the regularity of roof maintenance. Other factors which determine snow loads are wind speed and direction, ability of snow to be drifted and the presence of ventilation ducts, pipes, parapets, etc. The calculation of the effects of combining all these factors is very difficult and undoubtedly leads to complex relationships.

The problem may be approached by investigating only the principal causes and drawing conclusions which are verified in practice. Meteorological records and the shape and size of roof are the most important influences.

The influence of roof maintenance (snow clearing) can be considered from two points of view. Because of the difficulty and cost of snow removal snow loads should not be reduced because of anticipated snow removal. Also, the reduced cost of the building is sufficient to make snow removal desirable. The snow loads in "Structural Standards Regulations" take into account removal of snow from the roof.

Standard snow loads are determined as the mean of maximum yearly snow cover from 10 years of observations at a protected location, using a snow density of 0.2.

In deriving more precise values of snow load, the new specification "Structural Standards and Regulations" raised loads in the regions of Novosibirsk, Kemenof and Tobalsk to 150 kg/m^2 (31 psf) from 100 kg/m^2 (20 psf) in the earlier standard.

To assess the effect of snow load on deformation and failure of structures comparisons of stresses were made between the condition of actual (observed) snow loads and the condition of snow loads from the earlier standard.

Figure A-5 shows a truss-supported roof of a large industrial building and the triangular-shaped snow accumulation which caused structural collapse. A comparison of the truss-member stresses from dead load plus snow load in the earlier standard to dead plus actual snow load is shown in Fig. A-6. The actual snow load stresses greatly exceed the allowable design stresses in most members especially in those having small stresses and those directly loaded (e.g. bar V5 where the increase is from 688 to 1,822 kg/cm^2 '9,800 to 25,900 psi' or 165%).

The investigation of stress conditions in roofs having excessive deflections established that (i) roof structures which deformed excessively under the weight of snow were found to have defects; (ii) the density of snow causing deformation exceeded the average of newly fallen snow showing that snow was not cleared from the roof and thus became compressed; (iii) excessive deformations after snowfalls occurred in diverse geographic regions and; (iv) the snow on roofs was distributed irregularly and accumulated in lower sections.

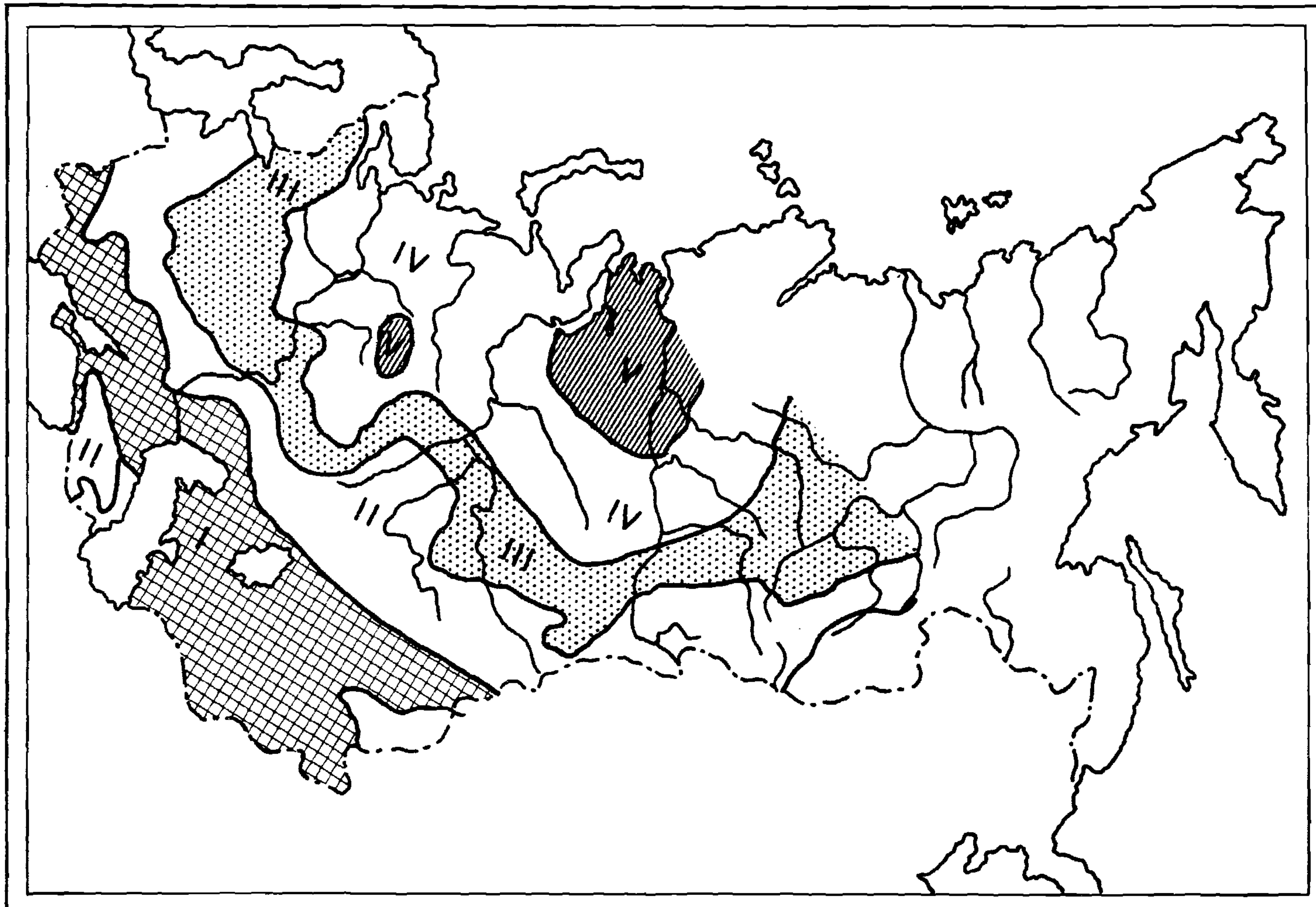
Field observations of snow accumulation were taken on some industrial buildings during the winter of 1954-55 near Moscow. A plan view of an industrial building with a two story lean-to (Fig. A-7) shows isolines of snow load which indicate how irregularly the snow is distributed accumulating at the walls in the shape of a triangle. The snow load in the triangular drift reached 350-400 kg/m^2 (72 to 82 psf) exceeding the standard specified load by 3.5 to 4 times whereas the total roof snow load did not exceed the total standard load.

References

A.1 Construction Standards and Regulations. Part II - Standards of Construction Planning. Gosudarstvennoe Izdatel'stvo Literatury po Stroitel'stvu i Arkhitecture. Moskva, 1954.

A.2 Kan Khut, E.D. The problem of snow load specification. Stroitel'naia Promyshlennost, No. 12, 1954, pp 23-23.

A.3 Gol' denblat, I.I., B.G. Korenev and A.M. Sizov. Snow loads according to "Construction Standards and Regulations". Stroitel'naia Promyshlennost, No. 6, 1956, pp 25-27.

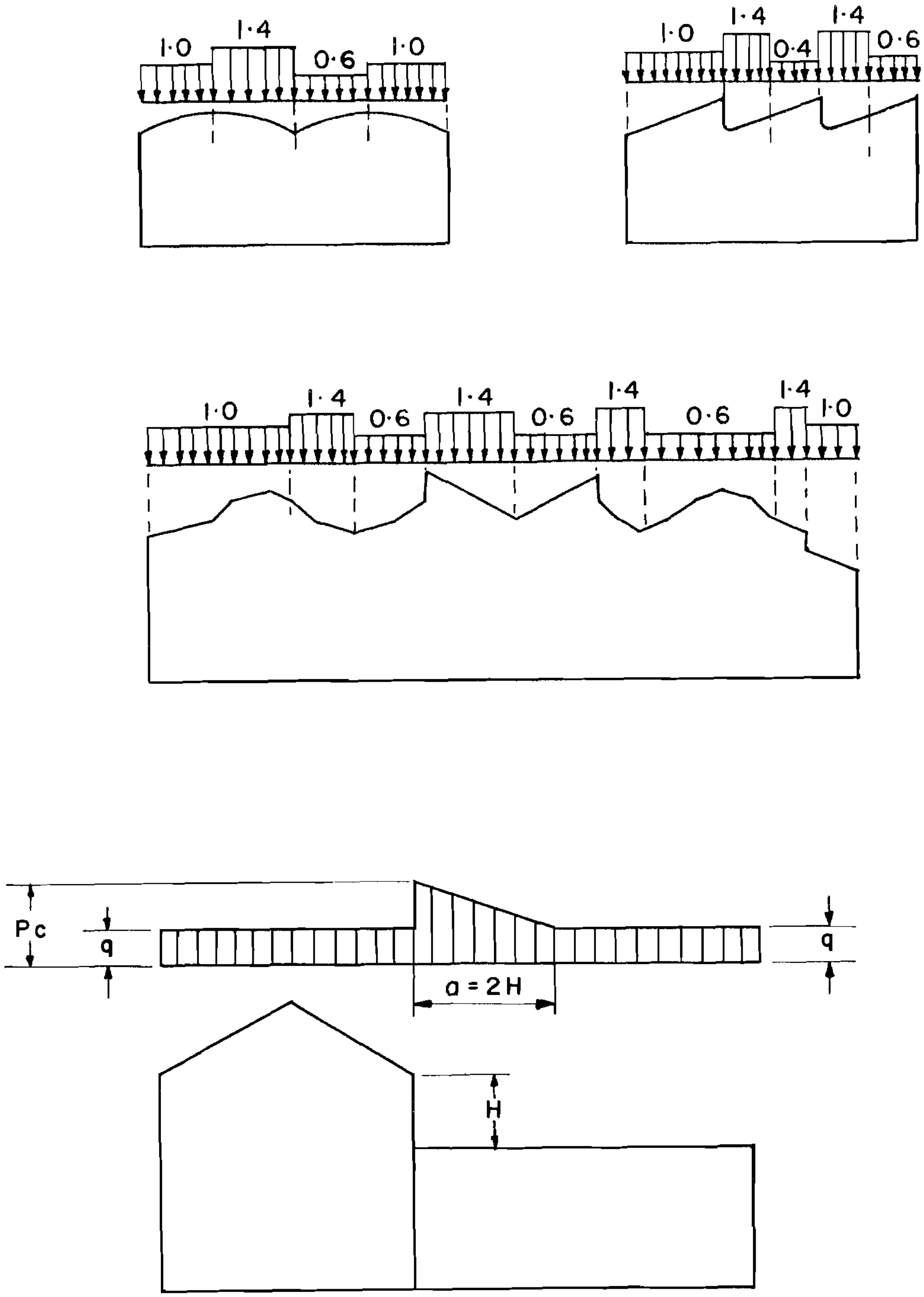


LEGEND

—·—·—·— BOUNDARY OF U.S.S.R.

——————— BOUNDARIES OF REGIONS USED FOR THE CALCULATION OF SNOW LOAD (EXCLUDING MOUNTAIN AREAS)

FIGURE A-I SNOW LOAD ZONES U.S.S.R.



Pc = 200H (METRES) BUT NOT LESS THAN q
NOR MORE THAN 4q

a = 2 H BUT NOT LESS THAN 5·0 M NOR MORE
THAN 10·0 M

FIGURE A-2

COEFFICIENTS FOR DESIGN SNOW LOADS FOR ROOFS WITH COMPLEX PROFILES

(WIND ASSUMED FROM THE LEFT)

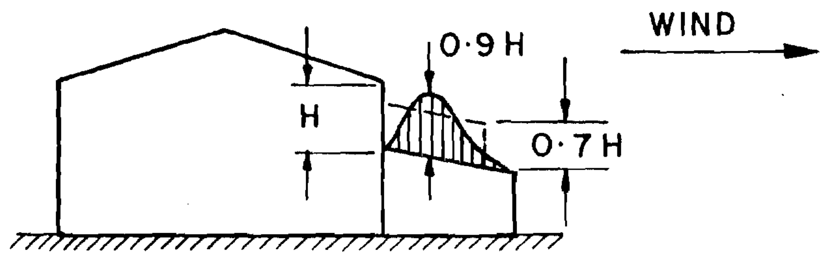


FIGURE A-3

SHAPE OF SNOWDRIFT ON A ROOF LEDGE

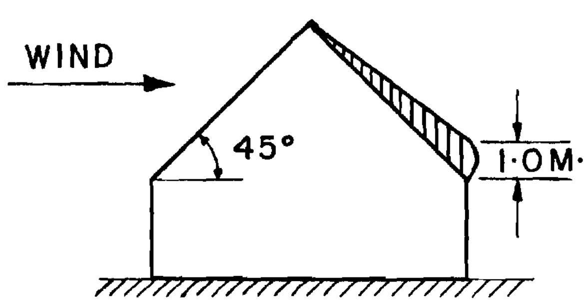


FIGURE A-4

SNOW DRIFT ON A STEEPLY PITCHED ROOF

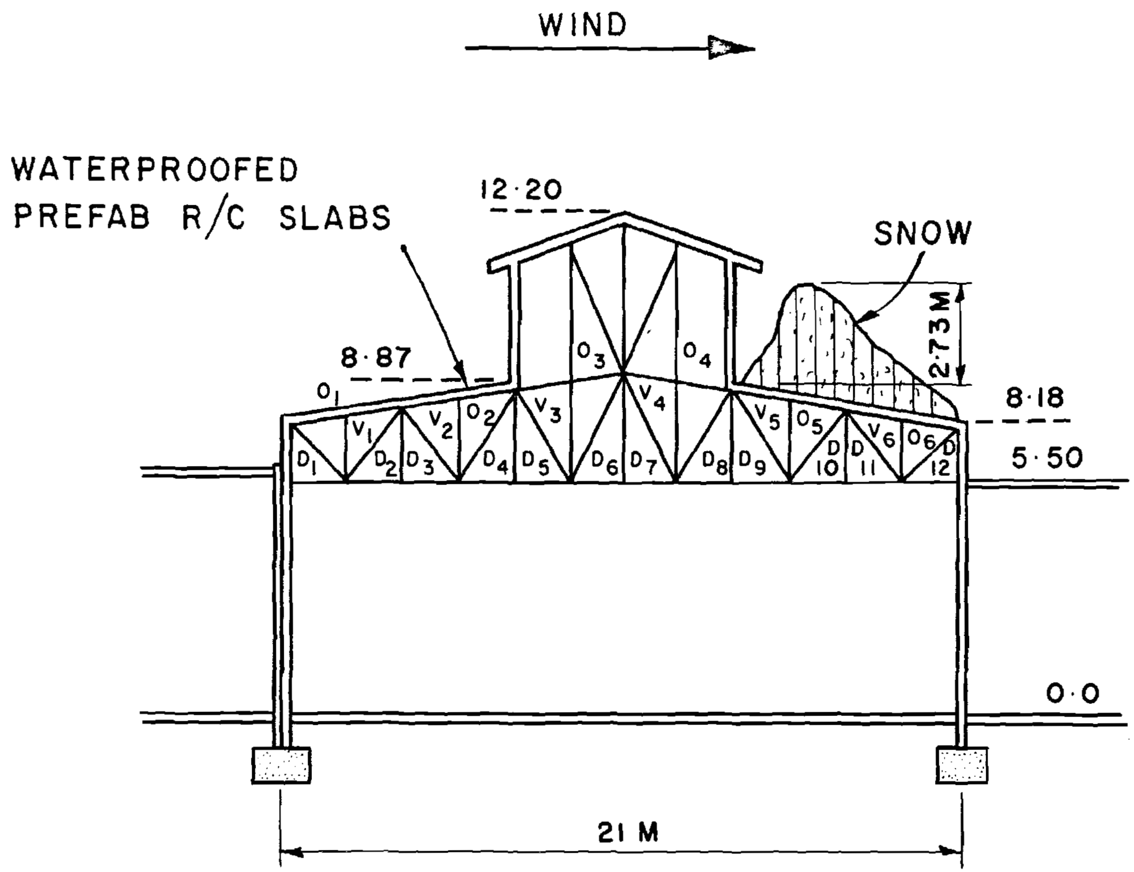


FIGURE A-5

CROSS-SECTION OF AN INDUSTRIAL BUILDING AND A TRIANGULAR SNOW ACCUMULATION

BR 1725-4

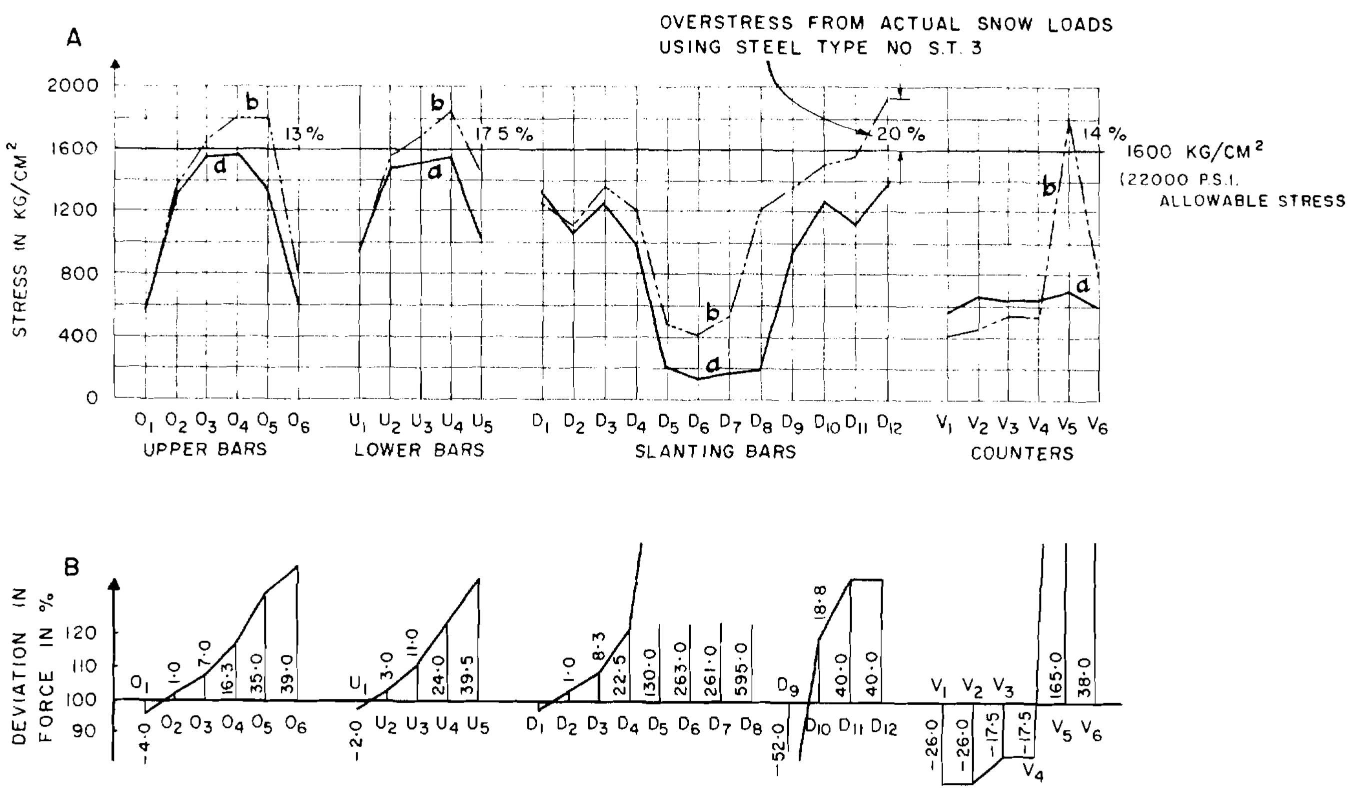


FIGURE A-6

THE INFLUENCE OF SNOW OVERLOAD ON THE CEILING TRUSS SHOWN IN FIG. A-5

A- STRESSES IN THE MEMBERS OF THE TRUSS FOR DIFFERENT TYPES OF LOADING; a - FROM THE PERMANENT LOAD ACCORDING TO THE DESIGN AND SNOW LOADS ACCORDING TO OST90058-40; b - FROM THE PERMANENT LOAD ACCORDING TO THE DESIGN AND ACTUAL LOADS OF SNOW;

B - THE DEVIATION OF FORCES IN THE MEMBERS OF THE TRUSS WITH DESIGN LOAD FORCES TAKEN AT 100 %

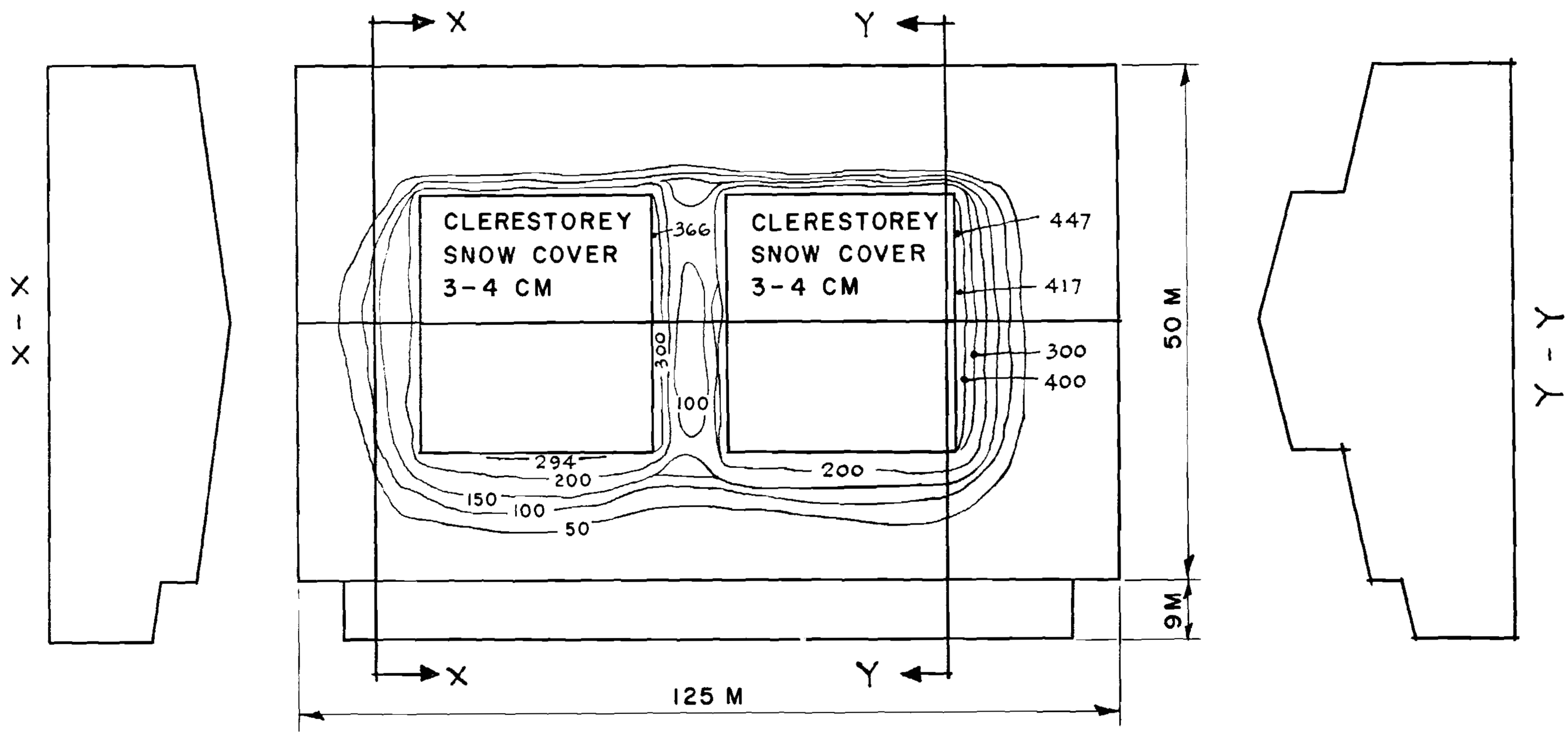


FIGURE A-7

PLAN OF ROOF OF BUILDING WITH CURVES OF EQUAL SNOW LOADS (KG/M^2)