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Snow Load Design Criteria for Steel Building Systems

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PREFACE

This Information Bulletin is intended as a guide for designers, specifiers and users of Steel Building Systems and as a reference for building code officials and other authorities.

The roof snow load magnitudes, distributions and special accumulations for which Steel Building Systems should be designed are illustrated. These are intended to meet or exceed the snow load provisions of the 1980 National Building Code of Canada.

Care has been taken to ensure that the information given herein is a reasonable interpretation of applicable Code requirements. The Canadian Sheet Steel Building Institute, however, assumes no responsibility for errors or oversights in the use of this information in the preparation of proposals, bids, specifications or designs.

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SNOW LOAD DESIGN CRITERIA FOR STEEL BUILDING SYSTEMS

BASIC ROOF SNOW LOAD

Manufacturers of Steel Building Systems who are members of the Canadian Sheet Steel Building Institute use the following criteria to establish minimum design snow loads, unless otherwise prescribed by the governing building regulations or the design authority.

(a) For all occupancy classifications and building sizes covered by Part 4 or 9 of the National Building Code of Canada 1980, eight-tenths (0.8) of the applicable ground snow load, except as noted in (b) [80 NBC Ref: 4.1.7.3.(1), 9.4.3.3, 9.4.3.4]

(b) For all occupancy classifications and building sizes covered by Part 4 or 9 of the National Building Code of Canada 1980, *where a reduced design snow load due to exposure to wind is permitted,* six tenths (0.6) of the applicable ground snow load. [80 NBC Ref: 4.1.7.4.(1)]

Note:
For arena-type assembly buildings, the Institute policy adopted in 1973 is re-affirmed, viz:

"A Steel Building System intended for use as an arena shall be designed for a minimum basic roof snow load equal to eight-tenths of the applicable ground snow load given in the National Building Code of Canada unless a professional consultant, on behalf of the owner, is responsible for the specification of design loads. In that case, the Steel Building System shall be designed for the snow loading which the consultant prescribes, on the understanding that the consultant accepts sole responsibility for the adequacy and suitability of any specified snow load less than that stipulated above."

SNOW LOAD DISTRIBUTIONS

The distribution of snow on roofs is strongly influenced by the effect of wind and by the shape of the roof. Therefore, in addition to being designed for a uniformly distributed snow load on all roof areas, Steel Building Systems are also designed to accommodate non-uniform snow loads such as those resulting from wind action, uneven melting, sliding, and other environmental conditions. Figure 1 illustrates the usual cases considered in the design of flat, single slope, gable and arch roofs.

SPECIAL CONDITIONS OF SNOW ACCUMULATIONS

Provision is also made for the likelihood of additional snow accumulation in roof valleys, on the lower of multi-level roofs, canopies, lean-to roofs and on areas adjacent to sizeable roof projections. Figure 2 illustrates typical examples.

NOTES

1. The diagrams in Figures 1 and 2 depict the pressures assumed to be exerted on a roof surface by a mass of snow. These pressures, or snow loads, are expressed in kilopascals (kPa) equal to kilonewtons per square metre* in SI metric, or in pounds per square foot (psf).

2. Snow load magnitudes are depicted by the symbols s or S_0 . The relationship is:

$$s = C_S S_0 \geq 1 \text{ kPa (21 psf)}$$

where s = basic design roof snow load or pressure
S_0 = established ground snow load or pressure
C_S = coefficient (0.8 or 0.6, as applicable)

The appropriate numerical value of S_0 is that given in the Building Code, or prescribed by the design authority for the locality concerned. Where the product $C_S S_0$ is less than 1 kPa (21 psf) use $s = 1$ kPa (21 psf).

3. The 1980 National Building Code requires, as did previous editions, that two snow load *distributions* be considered plus the effect of any special conditions of snow load *accumulations* resulting from shielding, sliding snow, etc. The likelihood that nonuniformity of snow load will be the prevailing mode increases as the tributary roof area under consideration is increased. Such nonuniformity may create an imbalance effect that is more critical to the supporting structure than a heavier mass of uniform snow.

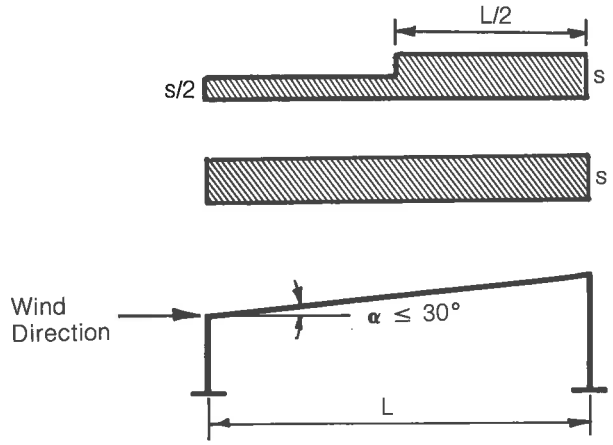
4. A minimum of two snow load *distributions* are considered in the design of structural members supporting larger roof areas (e.g. rigid frames, continuous beams, continuous purlins). For roof cladding, a uniform snow load is generally assumed for design purposes. Additional snow load *accumulations* are superimposed on the appropriate snow load *distributions*, where applicable. No special provision is made for the effects of full or partial snow removal, since removal is not recommended where design loads and safety margins are adequate.

**It is assumed that snow of depth, h, in metres and mass density ρ kg/m^3 exerts a pressure in kPa of $9.81 \times 10^{-3} \rho h$. Taking ρ as 240 kg/m^3, the pressure equals 2.35h (15h psf).*

FIGURE 1 – SNOW LOAD DISTRIBUTIONS ON ROOFS

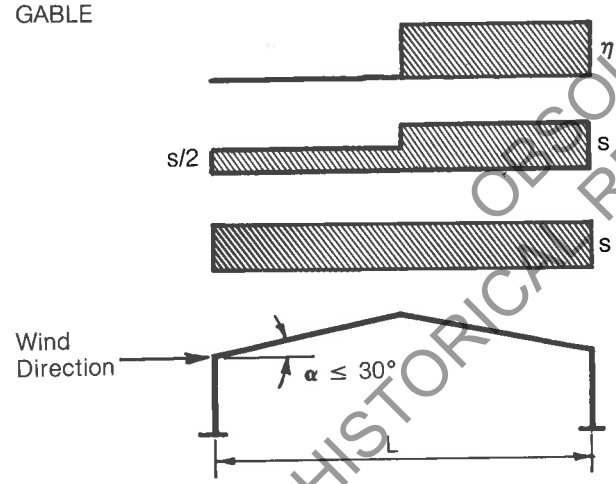
1(A) – SINGLE CLEAR SPANS

FLAT OR SINGLE SLOPE



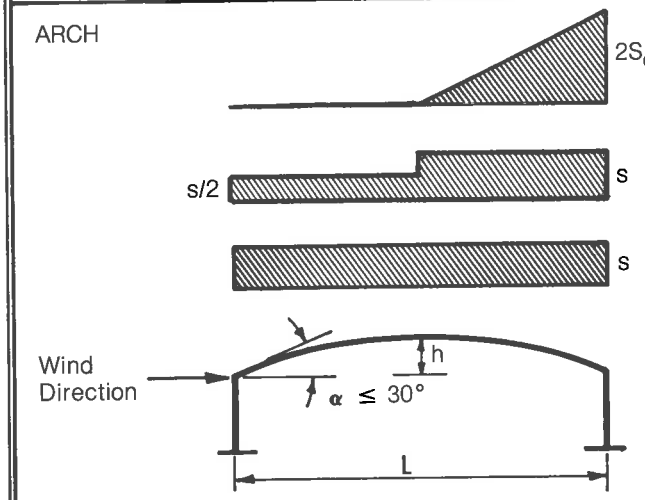
* Design for Case 1 and 2
* Case 2 includes "Opposite hand" distribution mode
* Case 2 may be critical for some truss-type roof members

GABLE



* Where $\alpha \leq 15°$, design for Case 1 and 2
* Where $\alpha > 15°$, design for Case 1 and 3
* Case 2 and 3 include "Opposite hand" distribution mode
* $\eta = 0.20 + \alpha/25 \leq 1.0$

ARCH

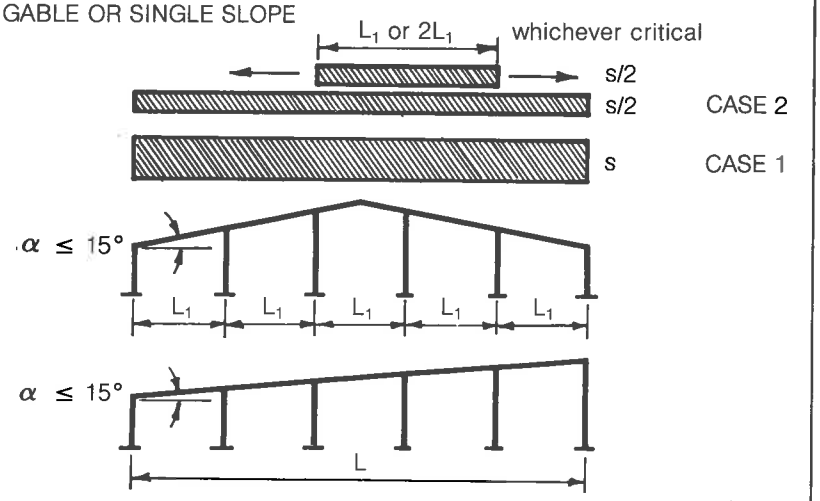


* Where h/L ≤ 0.1, design for Case 1 and 2
* Where h/L > 0.1, design for Case 1 and 3
* Case 2 and 3 include "Opposite hand" distribution mode

FIGURE 1 — SNOW LOAD DISTRIBUTIONS ON ROOFS (Cont'd)

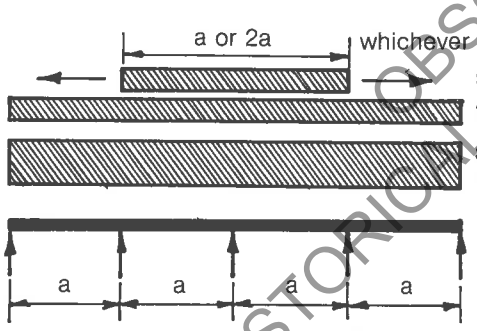
1(B) – CONTINUOUS BEAMS

GABLE OR SINGLE SLOPE



* Design for Case 1 and 2
* Unbalanced load (Case 2) starts and ends at a column

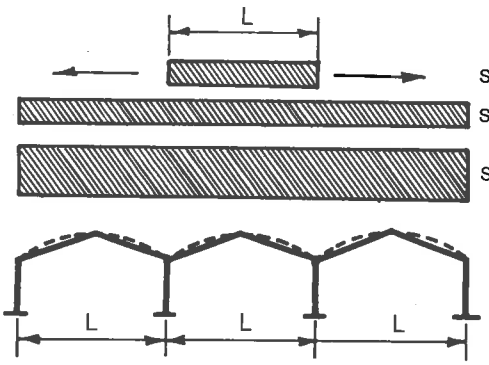
1(C) – CONTINUOUS PURLINS



* Design for Case 1 and 2
* For gable roof slopes ≤ 15° and arch roofs with h/L ≤ 0.1, use s
* For gable roof slopes > 15°, use ηS_0 as noted in Fig 1(A)
* For arch roofs with h/L > 0.1, see Fig 1(A)
* Unbalanced load (Case 2) starts and ends at a support

1(D) – MULTIPLE SPANS

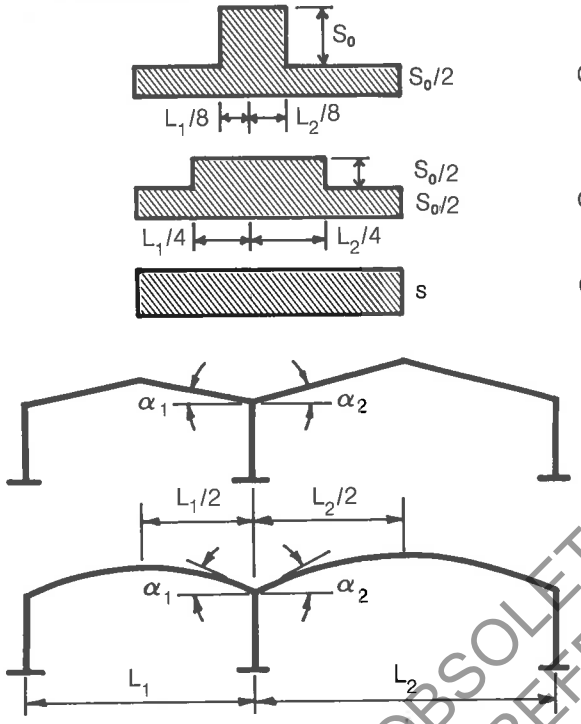
GABLE OR ARCH



* Design for Case 1 and 2
* Also design each span for loading as per Fig 1(A)
* Also design for snow accumulation in valleys as per Fig 2(A)
* Unbalanced load (Case 2) starts and ends at a column

FIGURE 2 – SNOW LOAD ACCUMULATIONS ON ROOFS

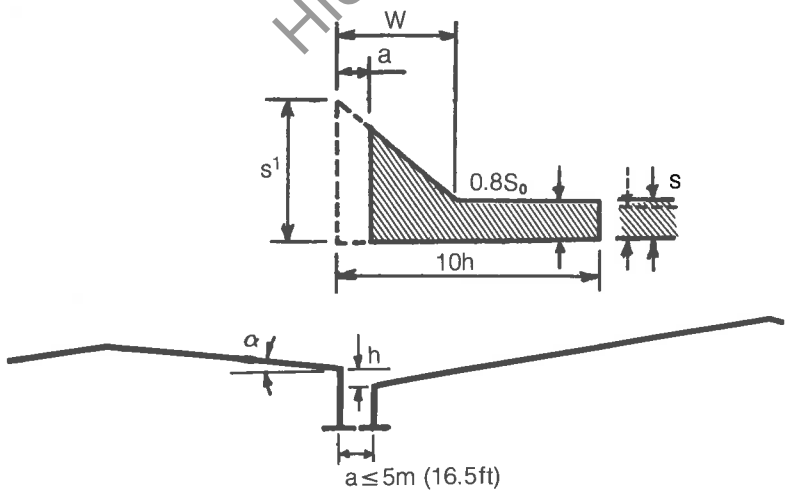
2(A) – ACCUMULATIONS IN VALLEYS



* Where both α_1 and $\alpha_2 \leq 10°$, design for Case 1 only
* Where α_1 and/or $\alpha_2 > 10°$ design for Case 1, 2 and 3

NOTE:
Portions of spans where loading is not indicated may be taken as uniformly loaded when determining the effects of snow accumulations in roof valleys

2(B) – ACCUMULATIONS ON LOWER OF MULTI-LEVEL ROOFS

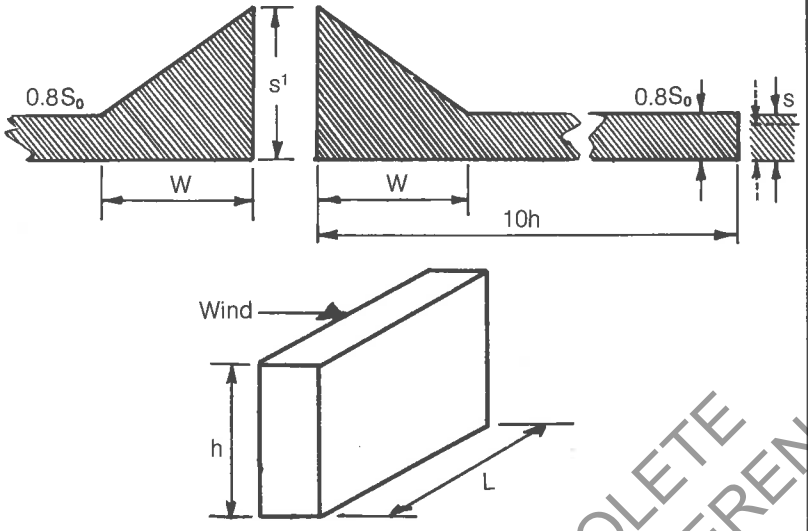


* W = 3m (10ft) where $h \leq 1.5m$ (5ft)
* W = 2h where 1.5m (5ft) $< h \leq$ 4.5m (15 ft)
* W = 9m (30ft) where $h >$ 4.5m (15ft)
* s^1 = 2.35h kPa (h in m) $\leq 3S_0$
  = 15h psf (h in ft) $\leq 3S_0$

NOTE:
Additional load from sliding snow should be considered. See Fig 2(D)

FIGURE 2 – SNOW LOAD ACCUMULATIONS ON ROOFS (Cont'd)

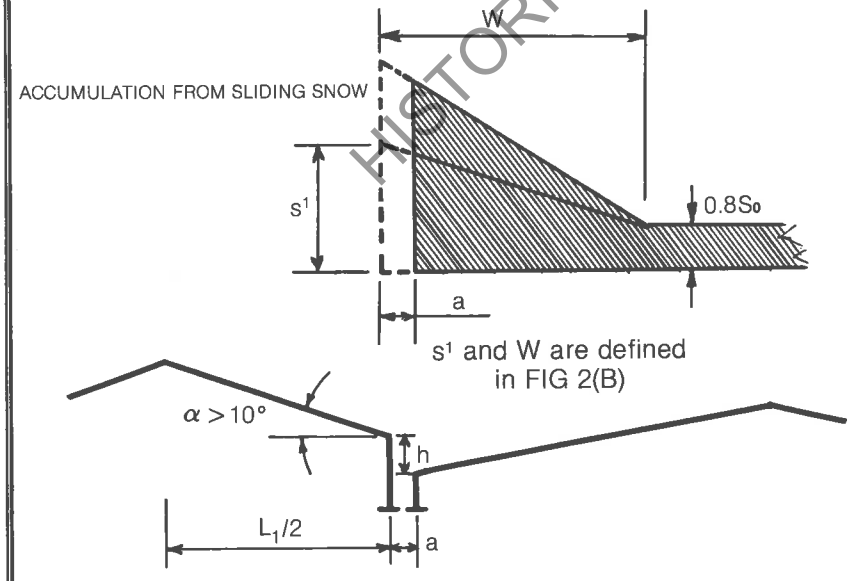
2(C) – ACCUMULATIONS ADJACENT TO PROJECTIONS



PROJECTION ON ROOF

* W = 3m (10ft) where
  h ≤ 1.5m (5ft)
* W = 2h where
  1.5m (5ft) < h ≤ 4.5m (15ft)
* W = 9m (30ft) where
  h > 4.5m (15ft)
* $s^1 = 0.8S_0$ where
  L(m) < S_0 (S_0 in kPa)
  L(ft) < $S_0/6$ (S_0 in psf)
* s^1 = 1.6h kPa (h in m) where
  L(m) ≥ S_0 (S_0 in kPa)
* s^1 = 10h psf (h in ft) where
  L(ft) ≥ $S_0/6$ (S_0 in psf)
  However, s^1 need not exceed $2S_0$

2(D) – ACCUMULATIONS FROM SLIDING SNOW



s¹ and W are defined in FIG 2(B)

HIGHER ROOF sloping more than 10° toward lower roof

LOWER ROOF

* Design lower roof for loading according to Fig 2(B), plus 50 percent of the snow on the portion of the upper roof which slopes towards the lower roof (i.e. 0.5 × s × $L_1/2$ per unit of building length)
* Distribute additional snow as indicated

NOTE:
Under certain conditions snow may slide when $\alpha \leq 10°$. Check where critical

Where snow build-up inhibits sliding, a reduced percentage may be taken

EXCERPTS FROM THE NATIONAL BUILDING CODE OF CANADA 1980*

PART 4 – DESIGN SECTION 4.1 – STRUCTURAL LOADS AND PROCEDURES

SUBSECTION 4.1.7. LIVE LOADS DUE TO SNOW AND RAIN

4.1.7.1. The specified load due to the accumulation of snow on a surface shall be not less than the ground snow load determined in conformance with Subsection 2.3.1., decreased or increased as provided for in Articles 4.1.7.2. to 4.1.7.4., but in no case shall the roof load be less than 1 kN/m² for roofs with a slope of 30° or less.

4.1.7.2.(1) The specified snow load on a roof or other *building* surface subject to loads due to snow accumulation shall be determined by multiplying the ground snow load given in Article 4.1.7.1. by appropriate snow load coefficient C_s given in Articles 4.1.7.3. and 4.1.7.4.

(2) A roof or other *building* surface and its structural members subject to loads due to snow accumulation shall be designed for the following snow load distributions:

(a) specified load distributed over the entire area,
(b) specified load distributed on any one portion of the area and half of this load on the remainder of the area, in such a way as to produce the greatest effects on the member concerned, and
(c) where appropriate, more severe load imbalances than given in Clause (b) which may result from such effects as snow removal or melting of snow due to roof fans or uninsulated roof areas in heated *buildings*.

4.1.7.3.(1) Except for roofs exposed to wind as provided for in Article 4.1.7.4., the basic snow load coefficient, C_s, is 0.8, which shall be increased or decreased to account for the following influences:

(a) the decrease of snow load because of the effect of slope for roof slopes exceeding 30°,
(b) the accumulation of nonuniform snow load on gable and hip roofs,
(c) the accumulation of nonuniform snow load on arched and curved roofs,
(d) the accumulation of increased snow loads in valleys of butterfly as well as multispan curved or sloped roofs,
(e) the accumulation of increased nonuniform snow loads due to drifting snow on the lower of 2-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 5 m away,
(f) the accumulation of increased nonuniform snow loads on areas adjacent to roof projections such as penthouses, large *chimneys* and ventilating equipment, and
(g) the accumulation of increased snow or ice loads on areas due to snow sliding or melt water draining onto these areas from an adjacent roof sloping towards this area so that the magnitude and distribution of the increase are appropriate to the relative portions and sizes of the surfaces. (See Appendix A.)

4.1.7.4.(1) The basic snow load coefficient of 0.8 may be reduced to 0.6 provided the *designer* has satisfactorily demonstrated that the following conditions are fulfilled:

(a) the *building* is located in an exposed location such as open level terrain with only scattered *buildings*, trees or other obstructions, so that the roof is exposed to the winds on all sides and is not likely to become shielded in the future by obstructions higher than the roof within a distance from the *building* equal to 10 times the height of the obstruction above the roof level, and
(b) the roof does not have any significant projection such as parapet walls, which exceed a height in metres of S_o divided by 4 where S_o is the ground snow load in kN/m², which may prevent snow from being blown off the roof.

4.1.7.5.(1) The specified load due to the accumulation of rain water on a surface, whose position and shape and deflection under load is such as to make such an accumulation possible, is that resulting from the 24 h rainfall determined in conformance with Subsection 2.3.1. over the horizontal projection of the surface and all tributary surfaces. (See Appendix A.)

(2) The provisions of Sentence (1) apply whether or not the surface is provided with drainage, such as rain water leaders.

(3) Loads due to rain need not be considered to act simultaneously with loads due to snow.

SUBSECTION 9.4.3. SNOW LOADS

9.4.3.1. Except as provided in Articles 9.4.3.2., 9.4.**3.3**. and 9.4.3.4., design snow loads shall be not less than 60 per cent of the appropriate ground snow load listed in Chapter 1 of the Supplement to the NBC 1980, but in no case shall the snow load be considered less than 1 kN/m^2 of horizontal roof projection.

9.4.3.2. Where the entire width of a roof does not exceed 4.3 m, the design snow load shall be not less than 50 per cent of the appropriate ground snow load listed in Chapter 1 of the Supplement to the NBC 1980, but in no case less than 1 kN/m^2 of horizontal roof projection.

9.4.3.3. Bow string, arch or semi-circular roof trusses having an unsupported span greater than 6 m, steel or wood roof framing members having an unsupported span greater than 12 m or a spacing greater than 600 mm and reinforced concrete roof slabs shall be designed in conformance with the snow load requirements in Section 4.1.

9.4.3.4. Except for roofs of wood-frame construction, roofs of *buildings* shall be designed in conformance with the snow-load requirements in Section 4.1 where the greatest horizontal area of the *building* above *grade*, measured within the exterior surfaces of the exterior walls, not withstanding the presence of *firewalls*, exceeds 600 m^2.

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