Snow Load Design Criteria for Steel Building Systems

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PREFACE

This 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 1985 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.

Much of the content of this Bulletin is taken directly from the Supplement to the National Building Code of Canada 1985, and has been expanded upon where additional explanation was considered helpful for understanding the application of these snow load provisions.

CONTENTS

SNOW LOAD DESIGN CRITERIA FOR STEEL BUILDING SYSTEMS

1. MINIMUM DESIGN SNOW LOADS

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 required by the governing building regulations or the design authority:

(a) For all occupancy classifications and building sizes covered by Part 4 or Part 9 of the National Building Code of Canada, the requirements of Subsection 4.1.7, "Loads Due to Snow, Ice and Rain", are followed;

(b) The ground snow loads and the snow load accumulation factors to be used in conjunction with (a) above are the values given in the Supplement to the National Building Code of Canada, Chapters 1 and 4 respectively.

2. DETERMINATION OF SNOW LOADS

2.1 **Specified Snow Load:** Snow loads on roofs vary according to geographic location (climate), site exposure, shape and type of roof, and also from one winter to another. To account for these varying conditions, the specified snow load, S, on a roof or other surface is expressed as the product of a series of factors

$$S = S_o \bullet C_b \bullet C_w \bullet C_s \bullet C_a$$

where,

S_o = the ground snow load by geographic location as listed in Chapter 1 of the Supplement to the National Building Code of Canada for selected locations in Canada, or as otherwise determined or specified

C_b = the basic roof snow load factor of 0.8

C_w = the wind exposure factor (see 2.2)

C_s = the slope factor (see 2.3)

C_a = the accumulation factor (see 2.4)

2.2 **Wind Exposure Factor, C_w:** Observations in many areas of Canada have shown that where a roof or a part of it is fully exposed to wind, some of the snow is blown off or prevented from accumulating and the average snow load is reduced.

Therefore, for roofs fully exposed to the wind, though not for very large roofs where it may be inappropriate, the wind exposure factor, C_w, may be taken equal to 0.75 rather than 1.0 provided that:

(a) the building is located in an open location containing only scattered buildings, trees or other such obstructions, so that the roof is exposed to the wind on all sides and is not shielded 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;

(b) the roof does not have any significant projections such as parapet walls which exceed a height of $0.25S_o$ metres; and,

(c) the loading case under consideration does not involve accumulation of snow due to drifting from adjacent surfaces such as, for example, the other side of a gable roof.

A value of C_w of 1.0 must be used in conjunction with Case 3 of Figure 1, Cases 2 and 3 of Figure 2(A), and Figures 2(B), 2(C) and 2(D).

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 specified roof snow load equal to 0.8 times 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 the 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."

2.3 **Slope Factor, C_s:** Under most conditions, less snow accumulates on steep than on flat and moderately sloped roofs, because of sliding, better drainage and other effects. The roof slope factor, C_s, accounts for these effects by reducing the snow load linearly from full snow load at a 30° slope to zero at a 70° slope. To be able to use the full slope reduction, the snow should not be restrained from sliding off the roof surface under consideration.

The roof slope reduction factor is taken as 1.0 for the purposes of this Bulletin since the applicability of this Bulletin extends only to roof slopes less than or equal to 30°.

2.4 **Accumulation Factor, C_a:** Due to the effects of wind encountering obstructions, uneven roof surfaces, and snow sliding off one surface onto another, there are many areas of a roof which can accumulate significantly higher snow loads. Figures 1 and 2 illustrate the accumulation factors to be used for these areas. Figure 1 illustrates the basic accumulation of snow on various roof types, while Figure 2 depicts the localized accumulations of snow in roof valleys, adjacent to projections, and resulting from snow sliding.

3. NOTES TO THE FIGURES

3.1 The 1985 National Building Code requires, as did previous editions, that two snow load distributions (Figure 1) be considered plus the effect of any special conditions of snow load accumulations (Figure 2) 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.

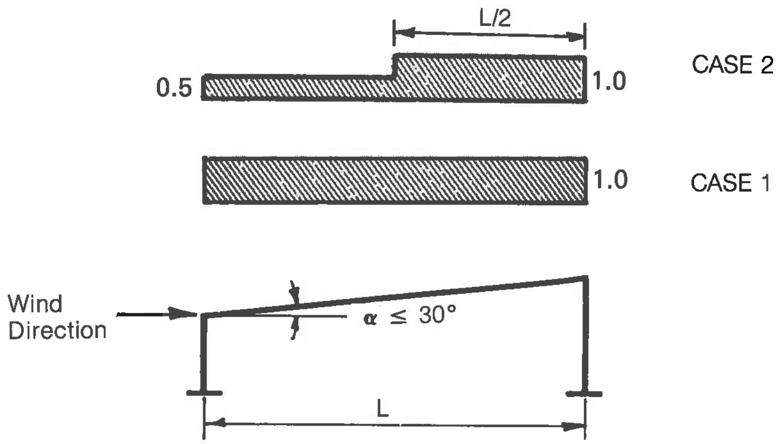
3.2 A minimum of two snow load distributions are considered in the design of structural members supporting larger roof areas (e.g. rigid frames, continuous beams, continuous purlins). For roof cladding, a uniform snow load is generally assumed for design purposes. Additional snow load accumulations are 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 necessary where design loads and safety margins are adequate, and may, in fact, cause damage to the roof surface.

3.3 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 245 kg/m^3, the pressure equals 2.4h.

FIGURE 1 — BASIC SNOW LOAD ACCUMULATIONS ON ROOFS

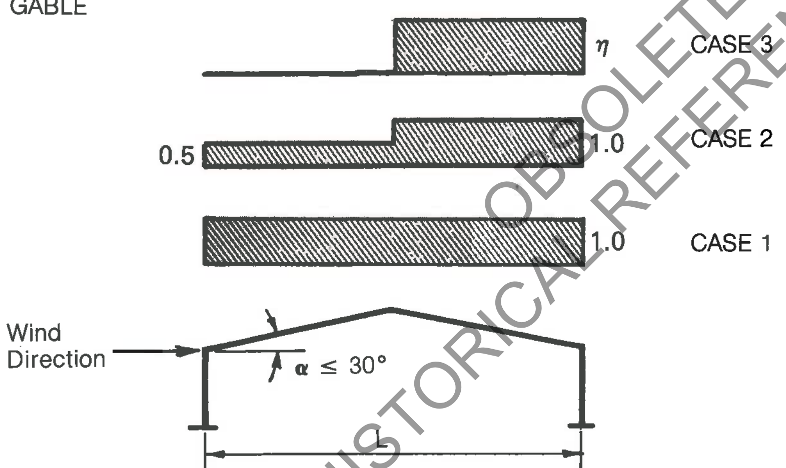
1(A) ACCUMULATION FACTOR, C_a, FOR SINGLE CLEAR SPANS

FLAT OR SINGLE SLOPE



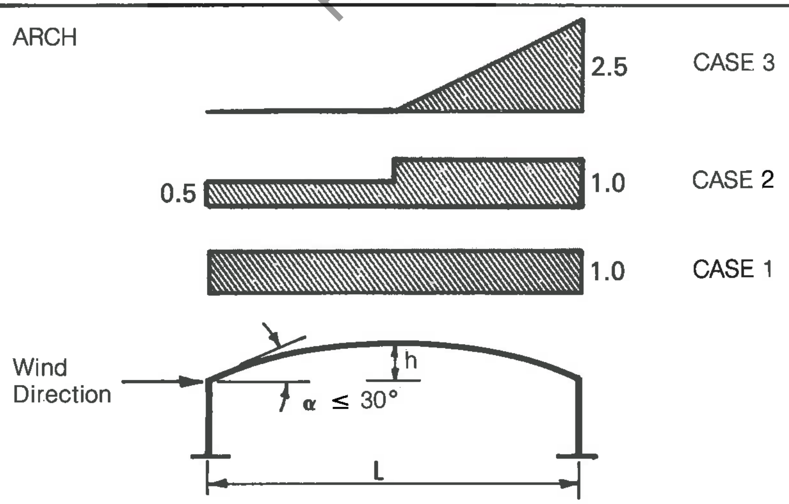
* Design for Case 1 and 2
* Case 2 includes "Opposite hand" distribution mode
* Case 2 may be critical for some truss-type roof members

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
* $\eta = 0.25 + \alpha/20 \leq 1.25$
* For Case 3, $C_w = 1.0$

ARCH

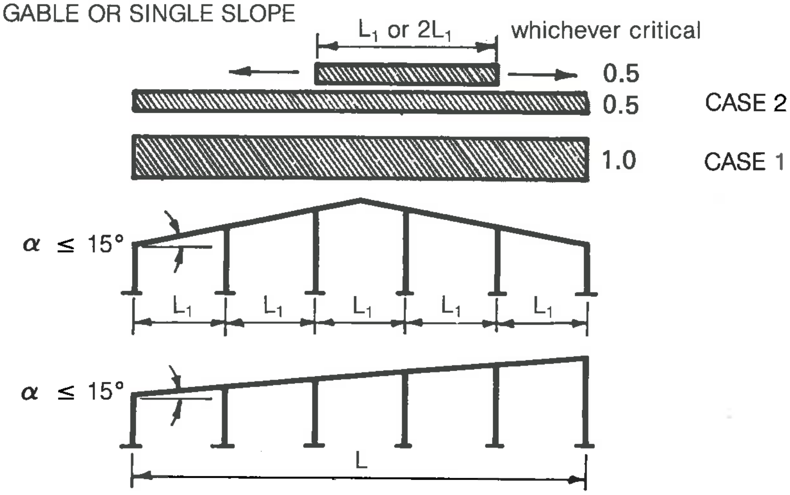


* Where $h/L \leq 0.1$, design for Case 1 and 2
* Where $h/L > 0.1$, design for Case 1 and 3
* Case 2 and 3 include "Opposite hand" distribution mode
* For Case 3, $C_w = 1.0$

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

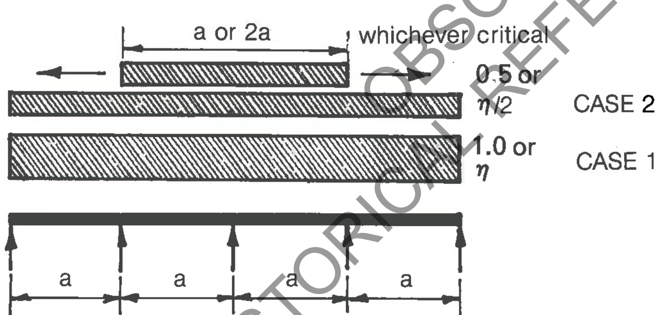
1(B) ACCUMULATION FACTOR, C_a, FOR CONTINUOUS BEAMS

GABLE OR SINGLE SLOPE



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

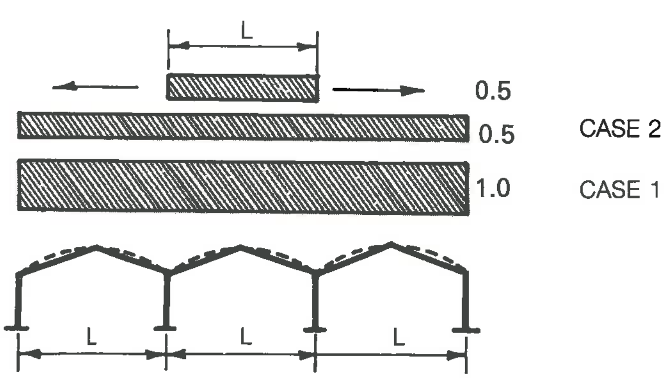
1(C) ACCUMULATION FACTOR, C_a, FOR CONTINUOUS PURLINS



* Design for Case 1 and 2
* For gable roof slopes $\leq 15°$ and arch roofs with $h/L \leq 0.1$, use 1.0
* For gable roof slopes $> 15°$, use η 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) ACCUMULATION FACTOR, C_a, FOR MULTIPLE SPANS

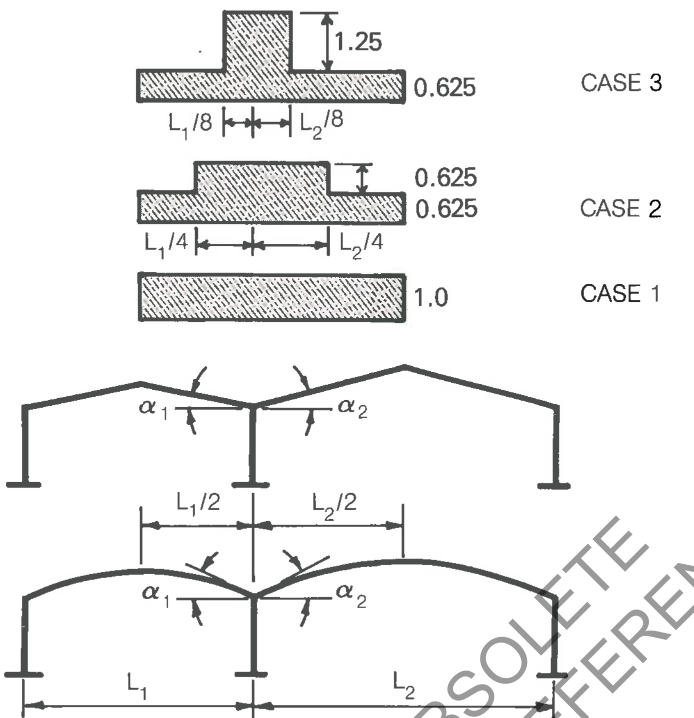
GABLE OR ARCH



* 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 — LOCALIZED SNOW LOAD ACCUMULATIONS ON ROOFS

2(A) ACCUMULATION FACTOR, C_a, FOR VALLEYS



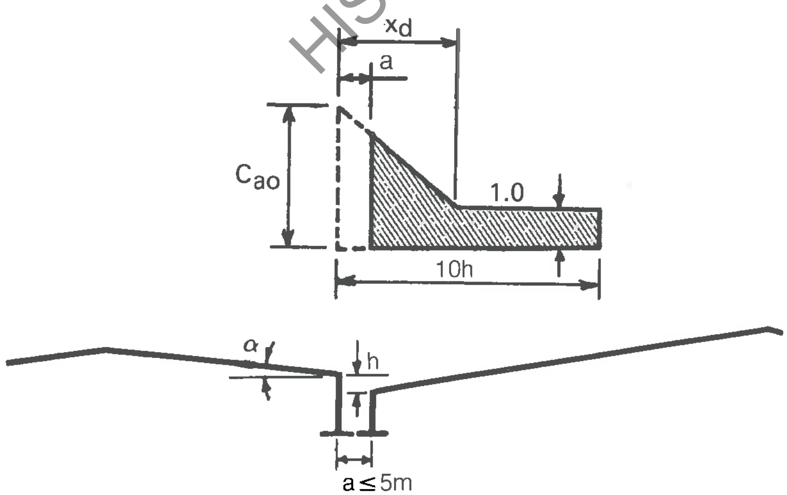
* Where both α_1 and $\alpha_2 \leq 10°$, design for Case 1 only

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

* For Cases 2 and 3, $C_w = 1.0$

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) ACCUMULATION FACTOR, C_a, FOR LOWER OF MULTI-LEVEL ROOFS



* $x_d = 2h$, but

  $3\ m \leq x_d \leq 9m$

* $C_{ao} = \frac{3h}{S_0}$, but

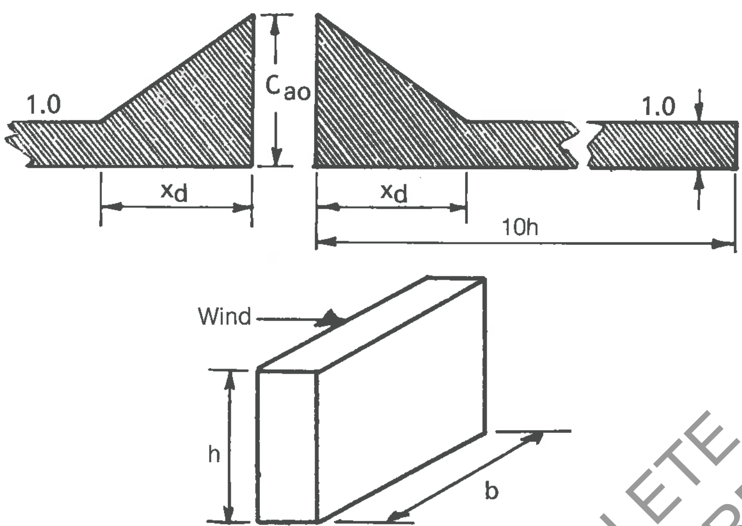
  $1.0 \leq C_{ao} \leq 3.75$

* $C_w = 1.0$

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

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

2(C) ACCUMULATION FACTOR, C_a, ADJACENT TO PROJECTIONS



PROJECTION ON ROOF

* For $b \leq S_o$, $C_a = 1.0$

* For $b > S_o$, C_a is shown in the Figure with x_d and C_{ao} determined as follows:

* $x_d = 2h$, but

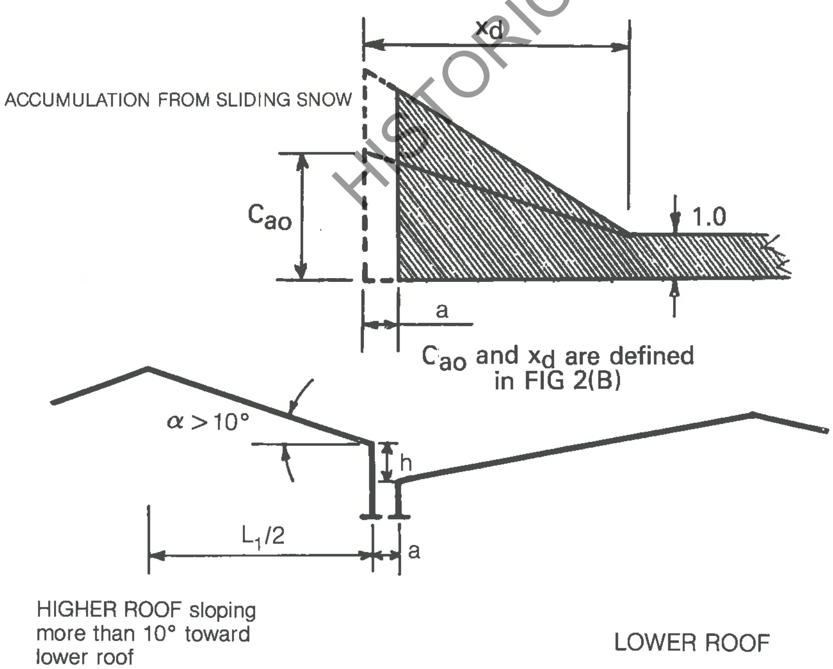
  $3m \leq x_d \leq 9m$

* $C_{ao} = \frac{1.9h}{S_o}$, but

  $1.0 \leq C_{ao} \leq 2.5$

* $C_w = 1.0$

2(D) ACCUMULATION FACTOR, C_a, FOR SLIDING SNOW



* 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. $0.5 \times S \times L_1/2$ per unit of building length)

* Distribute additional snow as indicated

* $C_w = 1.0$

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 1985*

PART 4 — Structural Design
SECTION 4.1 — Structural Loads and Procedures
SUBSECTION 4.1.7 — Loads Due to Snow, Ice and Rain

4.1.7.1.(1) The specified loading, S, due to snow accumulation on a roof or any other *building* surface subject to snow accumulation shall be calculated from the formula

$$S = S_o \cdot C_b \cdot C_w \cdot C_s \cdot C_a$$

where

S_o is the ground snow load in kPa, determined in accordance with Subsection 2.2.1.,
C_b is the basic roof snow load factor of 0.8,
C_w is the wind exposure factor in Sentence (2),
C_s is the slope factor in Sentence (4), and
C_a is the accumulation factor in Sentence (5).

(2) Except as provided for in Sentence (3), the wind exposure factor, C_w, shall be 1.0.

(3) The wind exposure factor in Sentence (2) may be reduced to 0.75 where

(a) the *building* is in an exposed location, so that the roof is exposed to the winds on all sides, with no obstructions higher than the roof located closer to the *building* than a distance equal to 10 times the height of the obstruction above the roof,
(b) the roof does not have any significant projections, such as parapet walls, that exceed a height of $0.25\ S_o$ metres, and
(c) the loading does not involve accumulation of snow due to drifting from adjacent surfaces.

(4) The slope factor, C_s, shall be

(a) 1.0 when the roof slope, α, is equal to or less than 30°,
(b) $1.0 - \left(\frac{\alpha - 30°}{40°}\right)$ when α is greater than 30°, but not greater than 70°,
(c) 0 when α exceeds 70°, and
(d) 1.0 when used in conjunction with accumulation factors for increased snow load as given in Clauses (5)(b)(ii) and (5)(b)(v). (See Appendix A.)

(5) The accumulation factor, C_a,

(a) shall be 1.0, and
(b) where appropriate for the shape of the roof, assigned other values which account for
  (i) non-uniform snow loads on gable, arched or curved roofs,
  (ii) increased snow loads in valleys,
  (iii) increased non-uniform snow loads due to snow drifting onto a roof which is at a level lower than other parts of the same *building* or at a level lower than another *building* within 5 m of it.

(iv) increased non-uniform snow loads on areas adjacent to roof projections, such as penthouses, large *chimneys* and equipment, and
(v) increased snow or ice loads due to snow sliding or drainage of meltwater from adjacent roofs.

(See Appendix A.)

4.1.7.2.(1) A roof or other *building* surface and its structural members subject to loads due to snow accumulation shall be designed for the specified load in Sentence 4.1.7.1.(1), distributed over the entire loaded area.

(2) In addition to the distribution in Sentence (1), flat roofs and shed roofs, gable roofs of 15° slope or less and arched or curved roofs with rise to span ratios equal to or less than 1/10 shall be designed for the specified uniform snow load in Sentence 4.1.7.1.(1), computed using $C_a = 1.0$, distributed on any 1 portion of the loaded area, and half of this load on the remainder of the loaded area, in such a way as to produce the greatest effects on the member concerned. (See Appendix A.)

4.1.7.3.(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 2.2.1. 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.

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CANADIAN SHEET STEEL BUILDING INSTITUTE

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