

AS/NZS 1170.3 Supplement 1:2003

Structural design actions—Snow and ice actions—Commentary (Supplement to AS/NZS 1170.3:2003)



AS/NZS 1170.3 Supp 1:2003

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AS/NZS 1170.3 Supplement 1:2003

Structural design actions—Snow and ice actions—Commentary (Supplement to AS/NZS 1170.3:2003)

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PREFACE

This Commentary was prepared by the Joint Standards Australia/Standards New Zealand Committee BD-006, General Design Requirements and Loading on Structures, as a Supplement to AS/NZS 1170.3:2003 *Structural design actions*, Part 3: *Snow and ice actions*. This Commentary supersedes AS 1170.3—1990, *Minimum design loads on structures—Snow loads—Commentary* (Supplement to AS 1170.3—1990) and, in part, NZS 4203:1992, *Code of practice for general structural design and design loadings for buildings* (Vol. 2).

The Commentary provides background material and guidance to the requirements of the Standard.

The clause numbers of this Commentary are prefixed by the letter ‘C’ to distinguish them from references to the Standard clauses to which they directly relate. Where a Commentary to a certain Clause is non-existent, it is because no explanation of the Clause is necessary.

It also provides advice and guidance on certain types of snow loads that cannot at this stage be covered by the Standard requirements (see Appendix CB on avoidance of common problems).

Worked examples that illustrate the application of some of the requirements of the Standard are given in Appendix CD.

ACKNOWLEDGEMENT

Standards Australia wishes to acknowledge and thank the following member who has contributed significantly to this Commentary:

Professor Peter Moss.

The photographs reproduced in Appendix CB of this Commentary were originally published in HB106: *Guidelines for Design of Structures in Snow Areas*, produced by the Institution of Engineers Australia. They are included here courtesy of the Institution of Engineers Australia and the Kosciusko National Parks and Wildlife Service.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Structural design actions—Snow and ice actions—Commentary
(Supplement to AS/NZS 1170.3:2003)**

SECTION 1 SCOPE AND GENERAL

C1.1 SCOPE

This Commentary is intended to be read in conjunction with AS/NZS 1170.3:2003 (Ref. 1). The Commentary includes explanations of the provisions of AS/NZS 1170.3 and, in some cases, suggests approaches that may satisfy the intent of the Standard. Commentary Clauses are not mandatory.

Appendices contain additional information on design and worked examples as follows (see also HB 106 (Ref. 3)):

- (a) Appendix CA—background to the loading equations and format of the Standard, including extracts from ISO 4355 (Ref. 2).
- (b) Appendix CB—common problems and their avoidance.
- (c) Appendix CC—methods for determining terrain classification.
- (d) Appendix CD—worked examples.

For assessment of snow action, the Standard considers the uniform snow that accumulates under calm air conditions, the shape of the roof and the snow pattern on the roof caused by windy conditions. For vertical loads on roofs, these influences are described in terms of shape coefficients (μ_i).

Methods are given for use in alpine areas where snow may accumulate for 3 or 4 months and for sub-alpine areas where it only lasts for a few days. Sub-alpine areas are where wind speeds are high and weather conditions are such that all the snow normally melts and clears between individual weather systems.

A load case corresponding to severe imbalances resulting from snow removal, redistribution, sliding, melting, etc. (e.g., zero snow load on specific parts of the roof) should always be considered. Such considerations are important for structures that are sensitive to the form of the load distribution (e.g., curved roofs, arches, domes or other structures).

C1.2 APPLICATION**C1.3 REFERENCED DOCUMENTS**

Documents referred to in this Supplement are as follows:

- 1 AS/NZS 1170.3, *Structural design actions*, Part 3: *Snow and ice actions*, Standards Australia.
- 2 ISO 4355, *Bases for design of structures—Determination of snow loads on roofs*, International Organization for Standardization.
- 3 HB 106, *Guidelines for design of structures in snow areas*, Standards Australia.

- 4 AS/NZS 1170.0, *Structural design actions Part 0: General principles*, Standards Australia.
- 5 ISO 3898, *Bases for design of structures—Notations—General symbols*, International Organization for Standardization.
- 6 AS/NZS 1170.2, *Structural design actions Part 2: Wind actions*, Standards Australia.
- 7 ISO 12494, *Atmospheric icing of structures*, International Organization for Standardization.
- 8 PHAM, L., *Statistical Analysis of Australian Ground Snow Load for Structural Design* First National Structural Engineering Conference 1987, Melbourne (conference papers).
- 9 EN 1991-2-3, *Basis of design and actions on structures Part 2.3: Actions on structures—Snow loads*, European Committee for Standardization.
- 10 McCLUNG, D.M., LARSEN, J.O. and HANSEN, S.B.; *Comparison of Snow Pressure Measurements and Theoretical Predictions*; Canadian Geotechnical Journal 21, Pages 250-258 (1984).
- 11 LARSEN, J.O., McCLUNG, D.M. and HANSEN, S.B.; *The Temporal and Spatial Variation of Snow Pressure on Structures*; Canadian Geotechnical Journal 22, Pages 166-171 (1985).

C1.4 DETERMINATION OF DESIGN ACTIONS

Where the Standard does not give a specific value for a design parameter or does not cover the particular circumstances of the design, a special study may be carried out. Parameters that may be established by a special study include the following:

- (a) Snow load or ice accumulation (using reliable data on snow depth and density or ice build-up and density at a particular site).
- (b) Values of other parameters (e.g., shape coefficients).

AS/NZS 1170.0 (Ref. 4) gives a procedure for carrying out special studies and on the use of testing. Special studies should be thoroughly documented in order to achieve an equivalent level of confidence in the resulting information as that achieved using the Clauses of the Standard (AS/NZS 1170.3).

C1.5 DEFINITIONS

All the definitions given in the Standard are drawn from ISO 4355 (Ref. 2), except those given for alpine regions and sub-alpine regions. Additional terms used in this supplement are as follows.

C1.5.1 Glaze

Clear high-density ice.

C1.5.2 Rime

White ice with in-trapped air.

C1.6 UNITS

The units used in the Standard are based on the SI units of metres, seconds, newtons and pascals.

C1.7 NOTATION

The notation used in the Standard has been based as far as possible, on ISO notation as given in ISO 4355 (Ref. 2) and ISO 3898 (Ref. 5). Definitions of notation appear under the first occurrence of that notation and are not repeated at every subsequent occurrence.

The notation used in this Supplement is as given in AS/NZS 1170.3 with the following additional notation:

d_g = depth of snow on the ground

C_t = thermal reduction coefficient

C_m = surface material coefficient

h = height above terrain

K_h = height factor for ice accumulation

s_b = balanced load component on roof

s_d = drift load component on roof

s_s = slide load component on roof

SECTION 2 SNOW REGIONS

C2.1 GENERAL

Although snow has been reported over a wide area in Australia, its effects are not always structurally significant. The occurrence of snow in New Zealand is greater, particularly in the South Island. Areas of New Zealand are also not subject to snowfalls that are structurally significant.

A significant snowfall is defined as that which results in an average snow accumulation on the ground of 175 mm or greater (annual probability of 1/150). Not all locations above 600 m in N.S.W., A.C.T. and Vic., and above 300 m in Tasmania (i.e., not all locations with a sub-alpine altitude) are subject to significant snowfall. Typical examples are Canberra and Armidale.

Icing is assumed to be relevant for alpine regions; however, the formation of ice is highly sensitive to conditions and its occurrence may need to be determined from local knowledge. See Section C3 for more guidance.

C2.2 AUSTRALIA

C2.3 NEW ZEALAND

The Australian and New Zealand maps (Figures 2.1 and 2.2) are only an approximate guide to regions with significant snow load. They do not give an accurate representation of the scale and size of all regions affected by snowfalls. Altitude should be used to determine whether a location is in an alpine region or sub-alpine region or not.

For sub-alpine regions, it is necessary to rely on local knowledge together with the data given in Section 5 to ascertain whether snow load is significant or not.

DIVISION OF REGIONS

The division into alpine and sub-alpine regions is necessary for three reasons:

- (a) The duration of snow load for alpine and sub-alpine regions is significantly different. For alpine regions, snow may be expected to stay on the roof for a significant proportion of the snow season. For sub-alpine regions, the snow load usually does not last for more than a few days at a time.
- (b) The design snow densities for these two regions are significantly different. For alpine regions, the average density when the maximum snow load occurs, is in the range of 400 to 500 kg/m³, whereas for sub-alpine regions, the average density is in the range of 250 to 300 kg/m³.
- (c) The shape coefficients for the two regions are different. The shape coefficients given for sub-alpine regions are appropriate for snow accumulated over a few days only, whereas more detailed shape coefficients are specified for alpine regions due to the much longer accumulations that occur (see Sections C6 and C7).

It is noted that in the alpine regions of Australia and New Zealand, snow is considerably more dense than European and North American snow (see also Clause C5.3).

SECTION 3 ICE ACTION

C3.1 GENERAL

The Standard specifies that icing needs to be considered where snow occurs; however, where structures are very tall or are at elevated sites, ice may form and the likelihood should be considered. The likely amount of ice accumulation would need to be investigated.

The occurrence of significant ice accumulation is affected by altitude, latitude and local conditions. The local topography at a site may greatly affect ice accretion (see effect of topography below). For example, for structures spanning wide areas, such as long cables, ice accumulation may be thicker on some parts of the structure while relatively thin on others. Local experience should be considered when determining ice actions in alpine regions.

Height above ground is also a significant parameter for the degree of ice action (see below).

STATIC ICE LOADS

Different types of structures are more or less sensitive to varying aspects concerning ice action. Some typical types of structures likely to be affected by ice are listed in Clause 3.1, but other types might be considered also. Some considerations are as follows:

- (a) Stretched-out steel ropes, cables, mast guys and similar are generally very sensitive to ice action and, therefore, tension forces in such elements may increase considerably in an iced condition.
- (b) Slender lattice structures, especially guyed masts, are sensitive to the increased axial compression forces from accreted ice on the structure.
- (c) Antennas and antenna structures can easily be overloaded by accreted ice, if this has not been foreseen. Fastening details are particularly vulnerable when increased load is added on top of other actions.
- (d) Covering materials (claddings and similar) can easily be deformed by the load of accreted ice, and damage can occur, if the ice has not fallen off before forces have grown too large.

Sensitivity of the structure to unexpected ice should be considered. In some cases, parts only of a structure may be sensitive rather than the whole structure.

The most vulnerable types of structures are cables, ropes and light lattice structures (e.g., guyed masts). Dynamic effects should be considered for these structures, especially the effect on natural frequencies of the structure as a result of the added weight of the ice. Shedding of ice from part of a structure may induce severe dynamic effects.

Falling ice may represent a hazard to those below the structure.

WIND LOADS ON ICED STRUCTURES

Structures like masts and towers together with stretched-out steel ropes, cables, mast guys and similar are sensitive to increased wind drag caused by icing. Wind load on iced structures should be calculated using the same principles as the wind load on the ice free structure.

Both the dimensions of the structural members and their drag coefficients are subject to changes. Therefore, proper values for the following parameters will need to be determined:

- (a) Likely amount of accumulation (see local experience and meteorological information).
- (b) Shape of accreted ice (see Clause C3.4).
- (c) Drag coefficients (see AS/NZS 1170.2; Ref. 6).

C3.2 DETERMINATION OF FORCES

Drag coefficients for ice classes for wind action

AS/NZS 1170.2 provides drag factors for wind loading. Where data is available to determine the appropriate ice class, ISO 12494 (Ref. 7) includes drag coefficients for a range of ice classes (both rime and glaze) based on object type, size and drag coefficient without ice.

C3.3 ICE DENSITY

Some guidance on ice density for rime and glaze is given in Clause C3.4.

C3.4 ICE THICKNESS

ISO 12494 (Ref. 7) gives ice types and densities, accumulation on various shapes and drag coefficients. These are based on Ice Classes (IC) related to an annual probability of exceedance of 1/50. The IC needs to be determined for the site of the structure in order to use ISO 12494 (Ref. 7). An appropriate annual probability of exceedance should be determined for use with the combinations in AS/NZS 1170.0 (Ref. 4).

ICING TYPES (EXTRACTS FROM ISO 12494)

General

Atmospheric icing is traditionally classified according to two different formation processes, that is—

- (a) precipitation icing; and
- (b) in-cloud icing.

ISO 12494 describes ice classes in terms of the accumulation of glaze and rime on standard objects. Classification is based on the parameters described in Tables C3.1 and C3.2. A Standard meter is defined in ISO 12494 (Ref. 7) as a rotating cylinder at least 500 mm long, 30 mm in diameter placed 10 m clear of the ground (or where snow can accumulate 10 m above the snow).

TABLE C3.1
TYPICAL PROPERTIES OF ACCRETED ATMOSPHERIC ICE

Type of ice	Density (kg/m ³)	Adhesion and cohesion	General appearance	
			Colour	Shape
Glaze	900	Strong	Transparent	Evenly distributed/icicles
Hard rime	600 to 900	Strong	Opaque	Eccentric, pointing windward
Soft rime	200 to 600	Low to medium	White	Eccentric, pointing windward
Wet snow	300 to 600	Weak (forming) strong (frozen)	White	Evenly distributed/eccentric

TABLE C3.2
METEOROLOGICAL PARAMETERS CONTROLLING
ATMOSPHERIC ICE ACCRETION

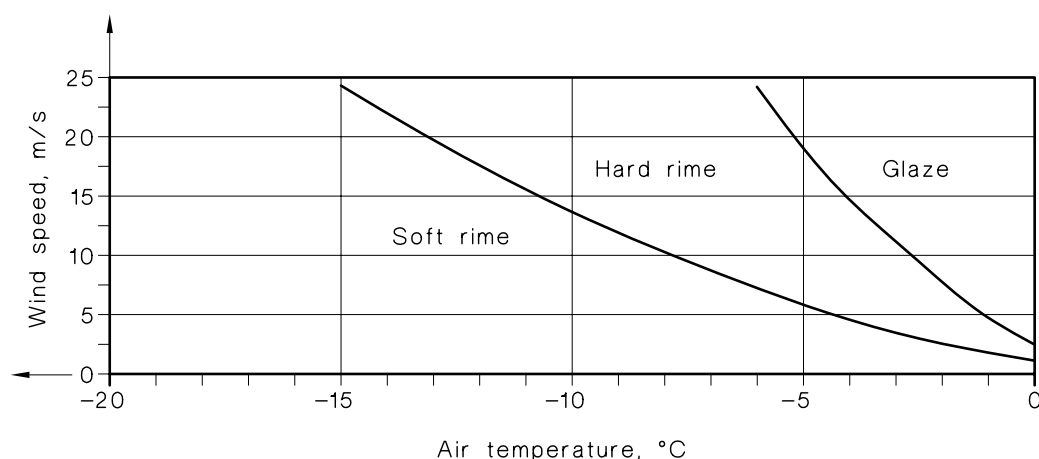
Type of ice	Air temperature (°C)	Wind speed (m/s)	Droplet size	Water content in air	Typical storm duration
Precipitation icing					
Glaze (freezing rain or drizzle)	-10 to 0	Any	Large	Medium	Hours
Wet snow	0 to +3	Any	Flakes	Very high	Hours
In-cloud icing					
Glaze	See Figure C3.1	See Figure C3.1	Medium	High	Hours
Hard rime	See Figure C3.1	See Figure C3.1	Medium	Medium	Days
Soft rime	See Figure C3.1	See Figure C3.1	Small	Low	Days

NOTE: When the flux of water droplets towards the object is less than the freezing rate, each droplet freezes before the next droplet impinges on the same spot, and the ice growth is said to be dry. When the water droplet flux increases, the ice growth will tend to be wet, because the droplets do not have time to freeze before the next one impinges. In general, dry icing results in different types of rime (containing air bubbles) while wet icing always forms glaze (solid and clear).

The physical properties and the appearance of accreted ice will vary widely according to the meteorological conditions present during the ice growth.

The maximum amount of accreted ice will depend on several factors, including the humidity, temperature and duration of the ice accretion. The main preconditions for significant ice accretion are the dimensions of the object exposed and its orientation to the direction of the icing wind.

Figure C3.1 gives an approximate indication of the parameters controlling the major types of ice formation. Wind speeds are 10 min mean values.



NOTES:

- 1 The wind speed on this graph is in terms of 10 min mean. Therefore, multiply the 3 s gust speed by 0.7 before applying the value to the graph.
- 2 The curves shift to the left with increasing liquid water content and with decreasing object size.

FIGURE C3.1 TYPE OF ACCRETED ICE AS A FUNCTION OF WIND SPEED AND AIR TEMPERATURE

Glaze

Glaze is the type of precipitation ice having the highest density. Glaze is caused by freezing rain or wet in-cloud icing, and normally causes smooth evenly distributed ice accretion (see Figure C3.2). Glaze may result also in formation of icicles; in this case the resulting shape can be rather asymmetric. Glaze can be accreted on objects anywhere when rain or drizzle occurs at temperatures below freezing point.

Freezing rain or drizzle occurs when warm air aloft melts snow crystals and forms rain drops, which afterwards fall through a freezing air layer near the ground. Such temperature inversions can occur in connection with warm fronts, or in valleys where cold air may be trapped below warmer air aloft.

The surface temperature of accreting ice is near freezing point and, therefore, liquid water, due to wind and gravity, can flow around the object and freeze also on the leeward side.

The accretion rate for glaze mainly varies with the following:

- (a) Rate of precipitation.
- (b) Wind speed.
- (c) Air temperature.

Conditions where glaze is heavy may lead to the formation of icicles, significantly increasing the loads from the mass of ice and from wind action on the ice shape.

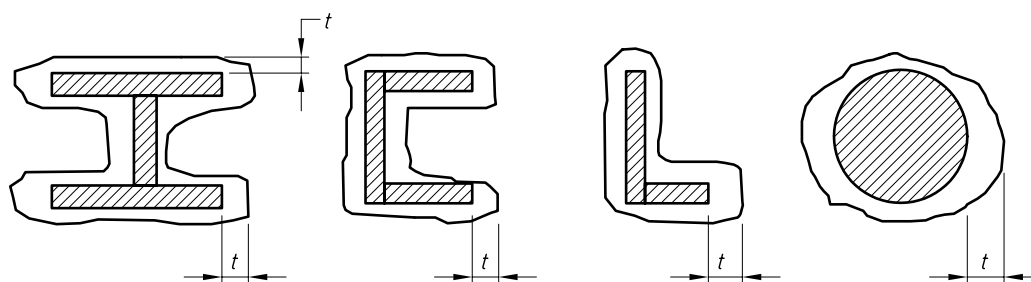


FIGURE C3.2 ICE ACCRETION MODEL FOR GLAZE

Wet snow

Wet snow is able to adhere to the surface of an object because of the occurrence of free water in the partly melted snow crystals. Wet snow accretion, therefore, occurs when the air temperature is just above the freezing point.

If decreasing temperature follows wet snow accretion, the snow will freeze. The density and adhesive strength vary widely with, among other things, the fraction of melted water and the wind speed.

Rime

Rime is the most common type of in-cloud icing and often forms vanes on the windward side of linear, non-rotatable objects (that is, objects that will not rotate around the longitudinal axis due to eccentric loading by ice).

During significant icing on small, linear objects, the cross-section of the rime vane is nearly triangular with the top angle pointing windward but, as the width (diameter) of the object increases, the ice vane changes its form (see Figures C3.3 and C3.4).

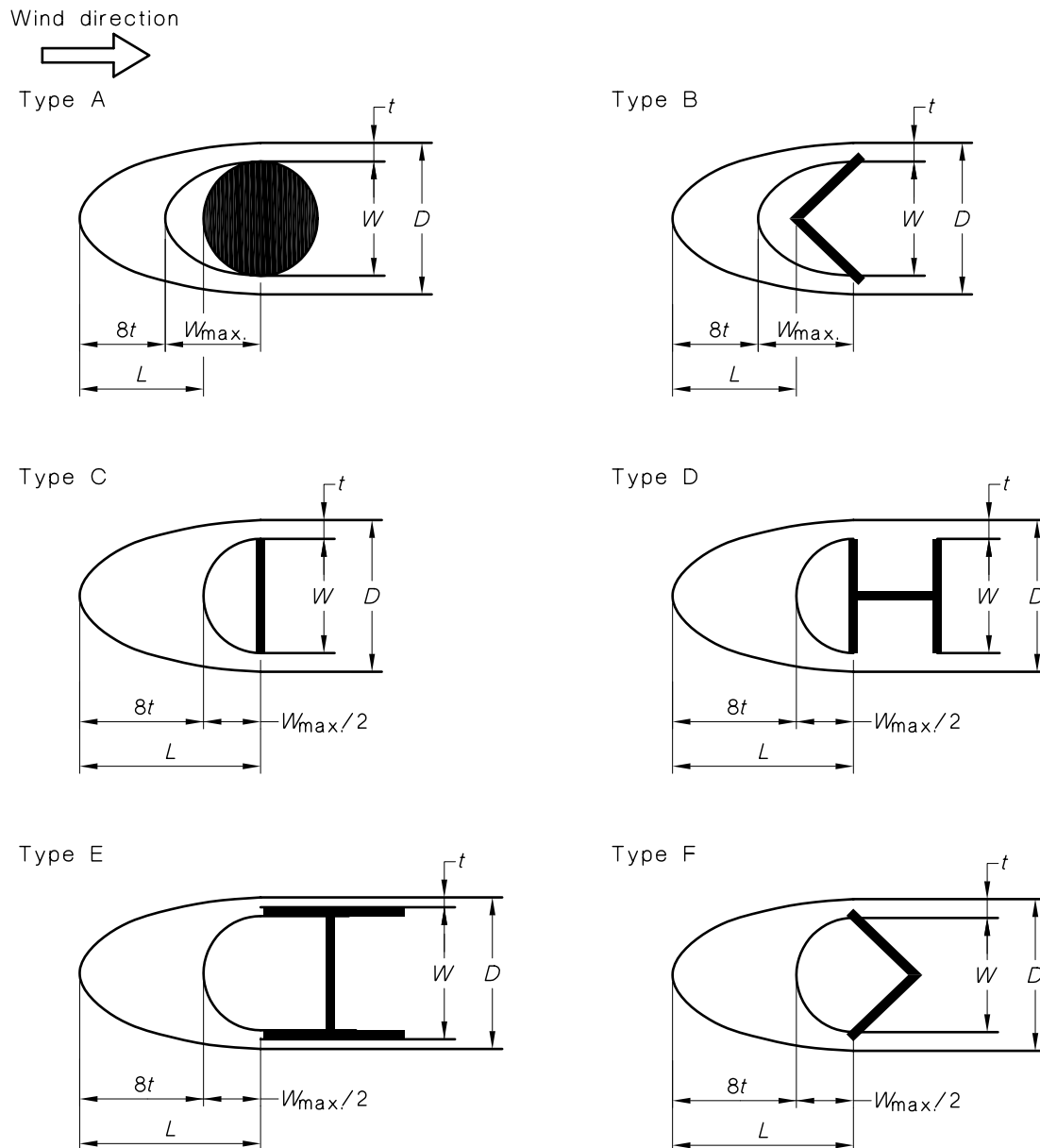


FIGURE C3.3 ICE ACCRETION MODEL FOR RIME

Evenly distributed ice can also be formed by in-cloud icing when the object is a (nearly) horizontal 'string' (linear shape), which is rotatable around its axis. The accreted ice on the windward side of the 'string' will force it to rotate when the weight of ice is sufficient. This mechanism may continue as long as the ice accretion is going on. It results in an ice accretion more or less cylindrical around the string.

The liquid water content of the air becomes so small at temperatures below about -20°C that practically no in-cloud icing occurs.

The most severe rime icing occurs on freely exposed mountains (coastal or inland), or where mountain valleys force moist air through passes, and consequently both lifts the air and increases the wind speed over the pass.

The accretion rate for rime mainly varies with the following:

- Dimensions of the object exposed.
- Wind speed.
- Liquid water content in the air.

- (d) Drop size distribution.
- (e) Air temperature.

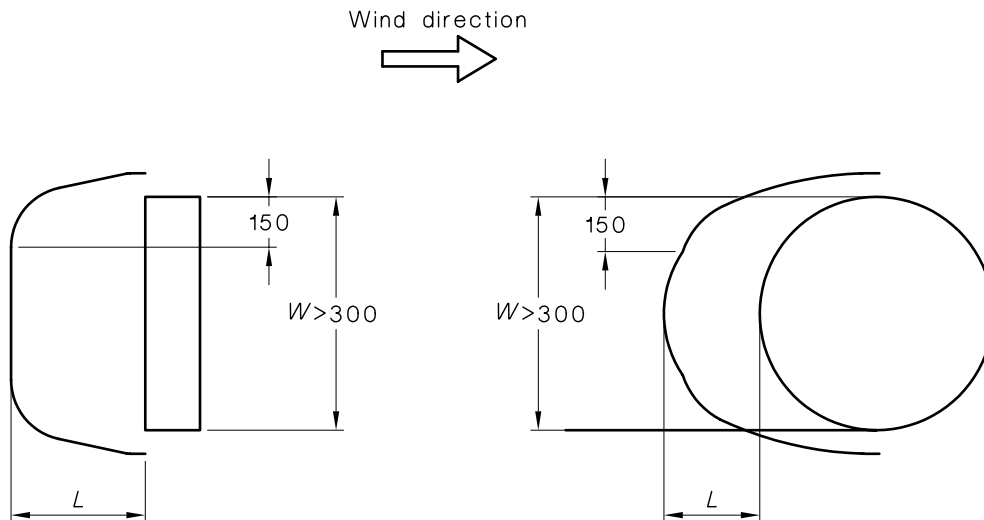


FIGURE C3.4 ICE ACCRETION MODEL FOR RIME—LARGE OBJECTS

Other types of ice

Hoar frost, which is due to direct phase transition from water vapour into ice, occurs at low temperatures. Hoar frost is of low density and strength, and normally does not result in significant load on structures.

TOPOGRAPHIC INFLUENCES (EXTRACTS FROM ISO 12494)

Regional and local topography modifies the vertical motions of the air masses and, hence, also the cloud structures' precipitation intensity and, by these, the icing conditions.

The influence of terrain is generally different for in-cloud icing than for precipitation icing. In general, topography may be the basis for defining icing regions. Most often a detailed description is necessary concerning the following:

- (a) Distance from the coast (to windward/leeward).
- (b) Elevation above sea level.
- (c) Local topography (plains, valleys).
- (d) Mountain sides facing maritime climates (to windward).
- (e) High-level areas sheltered by higher mountains.
- (f) High mountains situated on high level areas.

The most severe icing often occurs in mountain areas, where conditions can result in a combination of in-cloud and precipitation icing, where precipitation icing will normally be of the wet snow type.

When the wind is blowing from the sea, the mountains force the moist air upwards. This leads to condensation of water vapour and droplet growth on the windward side of the mountains due to cooling of the lifted, moist air. On the leeward side of the mountains, the cloudy air will descend and the water droplets (or ice crystals) will evaporate, resulting in dissolution of the clouds.

In a mountain area, a local face of a cliff only about 50 m height can give a significant reduction of in-cloud icing on the leeward vicinity of the cliff.

Additional lifting of the air by higher mountains, situated further inland, will cause new condensation and formation of clouds. But in this case, the passing of the coastal mountains has already reduced the liquid water content of the air. Therefore, the resulting icing at inland heights usually is less severe than the icing at the coastal heights.

In valleys, where cold air can be 'trapped', severe icing due to precipitation is more frequent in the valley bottoms than on the surrounding hillsides.

VARIATION WITH HEIGHT ABOVE TERRAIN (EXTRACTS FROM ISO 12494)

Ice mass on a structure may vary strongly with height of the element above terrain, but so far a simple model for the distribution of ice with height has not been found.

In some cases, ice may not be observed close to ground level, but at higher levels the ice load can be significant, and also the reverse situation may be found.

If heavy ice accretions appear probable, further meteorological studies on the particular site are recommended.

Figure C3.5 shows a typical multiplying factor for ice masses at higher levels above terrain (not above sea level). The graph represents the equation $K_h = e^{0.01h}$. The factor may be applied for all types of ice if site-specific data are not available, but reality may in some cases be more complicated than Figure C3.5 shows.

The height effect may be expressed also by specifying different ice classes for different levels of a high structure (e.g., masts, towers, ski-lifts and similar).

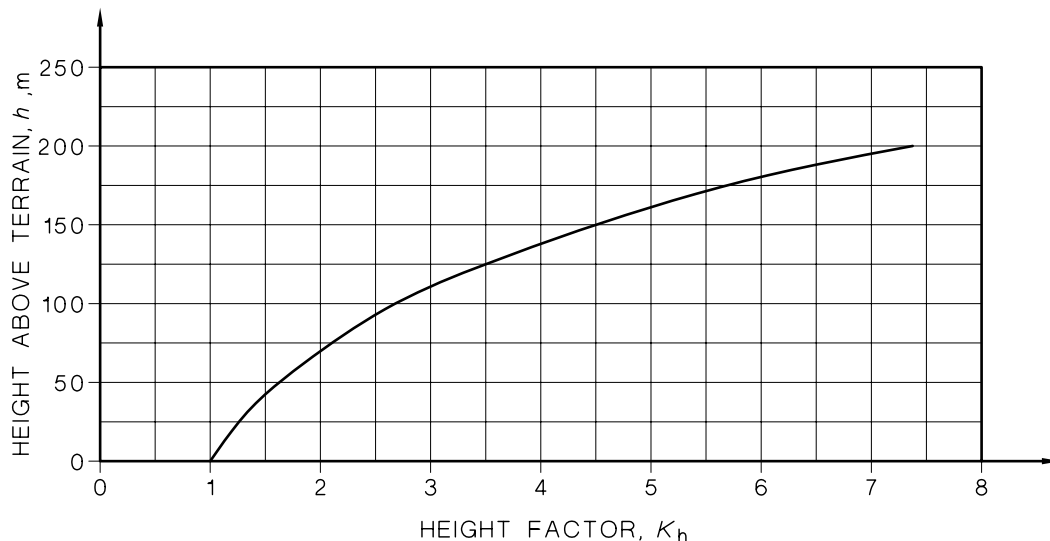


FIGURE C3.5 TYPICAL VARIATION OF ICE MASSES WITH HEIGHT ABOVE TERRAIN

SECTION 4 SNOW ACTION

C4.1 GENERAL

Snow can accumulate on a roof in many different patterns depending on the following:

- (a) Shape of the roof.
- (b) Thermal properties of the roof.
- (c) Roughness of the surface.
- (d) Amount of heat generated under the roof.
- (e) Proximity of nearby buildings.
- (f) Surrounding terrain.
- (g) Local meteorological climate, including—
 - (i) windiness;
 - (ii) temperature variation;
 - (iii) likelihood of precipitation (either as rain or as snow);
 - (iv) likelihood of accumulation from successive weather patterns; and
 - (v) variation in direction of wind during snow fall or in successive weather patterns.

Snow actions are modelled in the Standard by taking a value for ground snow load and multiplying by a shape coefficient. This is a simplification of the more complicated format given in ISO 4355; Ref. 2 (see extract given in Appendix CA).

C4.2 DESIGN SNOW LOADS

C4.2.1 Roof snow load

It is considered that roofs of buildings located in sub-alpine areas where the calculated ground snow load is less than 0.75 kPa (annual probability 1/150) have a very small risk of being exposed to high snow loads and a detailed design effort is not warranted. Therefore, a single evenly distributed load is given so that design is simplified. The design value given reflects the situation of a ground snow load of 0.75 kPa (single snow fall) on a normal structure in sheltered conditions (no wind) with a roof slope of 22 degrees. This is similar in value to the previously existing distributed roof live load of 0.25 kPa with a load factor of 1.5 specified in the 1989 Australian edition (AS 1170.1—1989).

UNBALANCED LOAD CASES

Snow seldom accumulates evenly on a roof. Snow may slide, be scoured by wind, or melt off part of a roof. This leads to reduced load on some sections of the roof.

In some cases, a reduction in snow load on part of the roof may result in increased stresses in certain structural members, such as continuous members with cantilevers, members of trusses, and similar.

On peaked and curved roofs, unbalanced snow load may develop due to the effects of sunlight and wind. Heat from the sun may cause snow on one half of the roof to melt more quickly or to slide off the roof. Wind may blow snow off the windward slope of the roof and deposit snow on the leeward slope of the roof.

C4.2.2 Exposure reduction coefficient

This factor has been established with reference to ISO 4355 (Ref. 2). It accounts for wind effects at the site of the structure.

In most locations, where a roof is exposed to wind on all sides, the wind blows a significant amount of snow off the roof.

This reduction applies only to alpine regions, because the maximum roof snow load in sub-alpine regions is usually the result of a single snowfall, which may or may not be accompanied by wind.

In practice, it is difficult to distinguish between roofs that will be exposed and roofs that will not. The roof may become shielded by an addition to the building or an adjacent taller building. The designer should ascertain if there are adjacent taller buildings or obstructions within 10 times the height of the obstruction above the roof or 25.0 m, whichever is the lesser.

The designer should assess the most appropriate exposure category based on knowledge and information on the site and wind conditions.

C4.2.3 Snow overhanging the edge of a roof

Sliding of snow in alpine regions sometimes results in snow remaining cantilevered over the edge of the roof for short or long periods of time. It generally forms a curved profile outwards and downwards from the edge. This imposes an extra load along the edge of the roof over which the snow slides.

C4.2.4 Snow actions on snowguards and obstructions

Where vertical projections are located on sloping roofs, the projection needs to be designed for lateral load due to snow sliding and creeping. In alpine regions, vertical projections on sloping roofs, such as vents and chimneys, have been dislodged or bent over by snow creep. Snow guards and snow diverters placed on sloping roofs, to prevent or divert snow from falling on people entering the building or on parked cars nearby, have also been dislodged from roofs, often causing damage to the roof.

Snow creep may also exert significant pressures on projections and obstructions located on slopes. Information on snow creep affecting buildings is given in Appendix CB.

On sloping roofs, the snow is likely to slide relative to the surface rather than creep (due to heating or when a thaw occurs). Therefore, the lateral force on projections may be calculated based on the assumption that the accumulated mass of snow slides relative to the surface.

SECTION 5 GROUND SNOW LOAD

C5.1 GENERAL

Ground snow loads have been given based on data collected at a large number of sites in Australia and New Zealand. The ground snow loads (s_g) given in the Standard are characteristic loads.

Generally, the ground snow load is the annual maximum ground snow load expected at a site with a given probability of exceedance. Values for particular sites are listed and equations are given for other locations. A Table of factors is provided to adjust the values for other annual probabilities of exceedance. No account has been taken of possible future changes to climate.

Values given for Australia are based on data collected over a 20-year period.

Values given for New Zealand have been revised taking recent information into account. For New Zealand, there is not a great deal of data available on snow loads. Some adjustments have been made to the values given previously for New Zealand, in order to simplify the use of the Standard.

Ground snow load is closely correlated to altitude. Therefore, values are given for each region varying with altitude. Snow also varies with latitude, but this is not a direct relationship as it can be affected by geographical regions and climate patterns.

In cases where the characteristic value of the snow action on the ground is determined for a particular site by a special study, the value should be obtained from an appropriate statistical analysis of long records of snow load taken in a well-sheltered area near the site. As there is usually a considerable variability in recorded maximum winter values over a number of years, records for periods of less than 20 years will not generally be suitable. The information should include the years of maximum snow depths, such as 1964 and 1981 in the Snowy Mountains (Southern highlands, Region AS).

C5.2 PROBABILITY FACTOR

AS/NZS 1170.0 (Ref. 4) requires design to be adjusted for risk according to the annual probability of exceedance specified. The probability factor provides for the calculation of ground snow load for different annual probabilities of exceedance. The factors given in this Table for Australia were determined from an analysis of the data collected before the previous edition (see paper by Dr L Pham, 1987, Ref. 8).

C5.3 GROUND SNOW LOADS FOR ALPINE REGIONS

For Australia, the basic equation for determining ground snow load (s_g) for alpine regions has been obtained from an analysis of data of snow depths and densities from the Snowy Mountains and extended to Tasmania using data for that area. For New Zealand, a similar equation has been adopted for the North Island and a modified equation for the South Island. This provides for higher design values for above 1200 m in the North Island and above 900 m in the South Island.

The variation of ground snow load with the topography and the exposure condition is very large. Where snow records or experience indicates that the ground snow loads given in these clauses are insufficient, higher ground snow loads should be used.

TERRAIN CLASSIFICATION (AUSTRALIA)

For Australian alpine regions, the depth of ground snow in a particular area is related to the terrain classification (k_t) which covers the effects of typical snow weather, topographical characteristics, exposure to wind and sun, and other factors. This factor has not been incorporated into the data for New Zealand. The Australian terrain classifications are based on studies of the area and information on local conditions, and are defined as follows:

- (a) Terrain classification 1: net removal of ground snow depth.
- (b) Terrain classification 2: no removal or increase of ground snow depth.
- (c) Terrain classification 3: net increase of ground snow depth.

Where no such effect has been observed, the classification of 2 leads to no variation of the ground snow loads (i.e., a factor of 1.0).

It is important to note the distinction between terrain classification and exposure reduction coefficient (see Clause C4.2.2). The terrain classification (k_t) applies to the amount of snow that falls and remains in the general area where the building is located. It takes into account macro features of the general area such as ranges, valleys, wind directions, etc. The exposure reduction coefficient (C_e) applies to the amount of snow that falls and remains on the roof or building surface under consideration. It takes into account micro features of the localized area such as protection from the wind by adjacent trees, other adjacent buildings, etc.

For methods of determining Australian terrain classifications and background on ground snow accumulation, see Appendix CC.

DENSITY OF ALPINE SNOW

The bulk weight density of snow varies. In general it increases with the duration of the snow cover and depends on the site location, climate and altitude.

Densities of snow for Australia and New Zealand are high due to the generally warm temperatures experienced and the resulting high proportion of water. Globally, snow density can vary from 1.0 kN/m³ for freshly fallen dry snow to more than 4.0 kN/m³ for wet snow.

For alpine regions in Australia, the snow weight, based on analysis of measured ground snow loads and depths, is in the range of 4.0 to 5.0 kN/m³. For design purposes, an average value of 4.3 kN/m³ of depth is specified. The same value has been assigned for alpine regions in New Zealand.

C5.4 GROUND SNOW LOADS FOR SUB-ALPINE REGIONS

C5.4.1 General

C5.4.2 Australia

For Australian sub-alpine regions, the characteristic loads given are based on the estimated maximum reported ground snow depth for a 20 year interval.

The variation of ground snow load with the topography and the exposure condition may be large. Where snow records or experience indicates that the ground snow load given in this clause is insufficient, a higher value should be used.

DENSITY OF FIRST-FALL SNOW

For sub-alpine regions, the snow weight is based on a measured *first fall* snow density of 2.9 kN/m³ obtained from records in the alpine regions, as there are no records of snow density in the sub-alpine regions.

C5.4.3 New Zealand

There is not a great deal of data available for snow loads in New Zealand. Ground snow loads are similar to those in the previous edition. Equations have been provided to enable the use of computer programs for design, including adjustment for annual probability of exceedance. Snow density has been taken to be 2.9 kN/m^3 .