INTERNATIONAL STANDARD

ISO 4355

Second edition
1998-12-01

Bases for design of structures — Determination of snow loads on roofs

Bases du calcul des constructions — Détermination de la charge de neige sur les toitures

ISO 4355:1998(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4355 was prepared by Technical Committee ISO/TC 98, *Bases for design of structures*, Subcommittee SC 3, *Loads, forces and other actions.*

This second edition cancels and replaces the first edition (ISO 4355:1981), which has been technically revised.

The first edition was based on knowledge available up to 1977.

Snow loads specified in the first edition were mainly based on a wide range of experience and national standards. Consequently, the specified snow loads in some cases were rather high in order to be on the safe side. In this second edition, later investigations (e.g. field measurements, physical, theoretical and statistical analyses) have also been taken into account in order to improve the level of accuracy and to extend the domain of standardized specifications of snow loads.

Although this second edition has more detailed specifications, there is still a need for judgement by experts in practical snow load design as the database is still very limited for many types of roof.

In national design standards for loads, load coefficients are normally used to take into account the uncertainty in calculated design load values.

Annexes A to F of this International Standard are for information only.

Introduction

The intensity and distribution of snow load on roofs may be described as functions of climate, topography, shape of building, roof surface material, heat flow through the roof, and time. Only limited and local data describing some of these functions are available. Consequently, for this International Standard it was decided to treat the problem in a semi-probabilistic way.

The characteristic snow load on a roof area, or any other area above ground which is subject to snow accumulation, is in this International Standard defined as the product of the characteristic snow load on the ground, s_0, specified for the region considered, and a shape coefficient μ which is defined as a product function, in which the various physical parameters are introduced as nominal coefficients.

The shape coefficients will depend on climate, especially the duration of the snow season, wind, local topography, geometry of the building and surrounding buildings, roof surface material, building insulation, etc. The snow may be redistributed as a result of wind action; melted water may flow into local areas and refreeze; snow may slide or may be removed.

The format for the snow load on roofs presented in this International Standard contains a number of additional parameters as compared with the first edition (in which such additional parameters were discussed in the text) for the designer to decide upon. In essence, however, the general format has not been changed. The effect of exposure may, with the new format, be treated in a more elaborate way than earlier. A variation with the slope of the roof is introduced in order to improve the physical representation and to make the format easily applicable to computer interpretation.

In order to apply this International Standard, each country will have to establish maps and/or other information concerning the geographical distribution of ground snow load in that country. Procedures for a statistical treatment of meteorological data are described in annex A.

Bases for design of structures — Determination of snow loads on roofs

1 Scope

This International Standard specifies methods for the determination of snow load on roofs.

It will serve as a basis for the development of national codes for the determination of snow load on roofs.

National codes should supply statistical data of the ground snow load in the form of zone maps, tables or formulae.

The shape coefficients presented in this International Standard are prepared for design application, and may thus be directly adopted for use in national codes, unless justification for other values is available.

For examining the effect of the wind on the distribution of snow loads on roofs of unusual shapes or shapes not dealt with in this International Standard or in national standards, suitable models (e.g. tests carried out in a wind tunnel especially equipped for reproducing accumulation phenomena) may give significant results.

The annexes describing methods for determining the characteristic snow load on the ground, exposure coefficient, thermal coefficient and loads on snow fences are for information only as a consequence of the limited amount of documentation and available scientific results.

In some regions, single winters with unusual weather conditions may cause severe load conditions not taken into account by this International Standard.

Specification of standard procedures and instrumentation for measurements is not dealt with in this International Standard.

2 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1
characteristic snow load on the ground
s_0
load with accepted probability of not being exceeded during some reference period, T_r years

NOTE 1 It is expressed in kilonewtons per square metre (kN/m^2).

NOTE 2 In meteorology the term “weight of the ground snow cover” is also used.

2.2
value of snow load on roofs

s

product of the characteristic snow load on the ground and an appropriate nominal shape coefficient

NOTE 1 The value of s is also dependent on the exposure of the roof and the thermal characteristics of the building.

NOTE 2 It refers to a horizontal projection of the area of the roof.

NOTE 3 It is expressed in kilonewtons per square metre (kN/m^2).

2.3
nominal shape coefficient

μ_i

shape coefficient with primary dependence on the geometry of the roof, in particular the roof slope

NOTE It is dimensionless.

2.4
slope reduction coefficient

μ_b

coefficient defining the reduction of the snow load on the roof due to a slope of the roof, β, and the surface material coefficient

2.5
drift load coefficient

μ_d

coefficient which, multiplied by μ_b, defines the amount and distribution of additional load on a leeward side or part of a roof, depending on the exposure of the roof and the geometrical configurations of the roof

2.6
slide load coefficient

μ_s

coefficient defining the amount and distribution of the slide load on a lower part of a roof, or a lower level roof

2.7
exposure reduction coefficient

C_e

coefficient defining the balanced load on a flat horizontal roof of a cold building, as a fraction of the characteristic snow load on the ground

NOTE 1 The exposure coefficient includes the effect of snow being removed from flat roofs by wind. This effect depends on the temperature and the corresponding wind of the region.

NOTE 2 It is dimensionless.

2.8
thermal reduction coefficient

C_t

coefficient defining the reduction of the snow load on the roof as a function of the heat flux through the roof, causing snow melting

NOTE It is dimensionless.

2.9
surface material coefficient

C_m

coefficient defining a reduction of the snow load on roofs made of surface materials with low surface roughness

3 Snow load on roofs

3.1 General function describing intensity and distribution of the snow load on roofs

Formally, the snow load on roofs may be defined as a function, F, of several parameters. Thus

$$s = F\,(s_0, C_e, C_t, C_m, \mu_b, \mu_d, \mu_s) \qquad \text{.. (1)}$$

where the symbols are as defined in clause 2.

Since the functional form and relative dependence of the various parameters of the function F of equation (1) are not documented yet, the determination of snow load on roofs must be obtained through approximations of the function F of equation (1).

While C_e, C_t and C_m are assumed constant for a roof or a roof surface, μ_b, μ_d and μ_s will generally vary throughout the roof.

3.2 Approximate formats for the determination of the snow load on roofs

The assumption that the snow load on the roof will be proportional to the characteristic snow load on the ground has led to the widely used format:

$$s = s_0\,\mu\,(C_e, C_t, C_m, \mu_b, \mu_d, \mu_s) = s_0\,\mu \qquad \text{... (2)}$$

NOTE For values of C_t different from unity, C_t is defined as a function also of s_0. This is due to the lack of data for short-term snowfall intensity. Moreover, in cases when the μ_d and μ_s coefficients are dependent on the amount of snow on a higher level roof, these coefficients are defined as functions of s_0. This is also the case when geometrical edge values are defined.

The functions μ of equation (2) depend on a number of parameters, and require extensive specifications and illustrations for various kinds of roof configurations, roof exposure, roof temperature, roof material, etc.

This International Standard defines the snow load on the roof as the sum of a balanced load, s_b, a drift load part, s_d, and a slide load part, s_s. Thus, for the most unfavourable condition (lower roof on leeward side):

$$s = s_b + s_d + s_s \qquad \text{... (3)}$$

Effects of the various parameters are simplified by the introduction of product functions. Thus,

$$s_b = s_0 C_e\, C_t\, \mu_b \qquad \text{... (4)}$$

$$s_d = s_0 C_e\, C_t\, \mu_b\, \mu_d \qquad \text{... (5)}$$

$$s_s = s_0\, C_e\, C_t\, \mu_s \qquad \text{... (6)}$$

The balanced load, s_b, is uniformly distributed in all cases, except for curved roofs, where the distribution varies with the slope β (see 5.4.5.5).

The balanced load defines the load on a horizontal roof, and the load on the windward side of a pitched roof. Since any direction may be the wind direction, the balanced load is treated as a symmetrical load on a symmetrical roof, thus defining a major part of the total load on the leeward side as well.

The drift load is the additional load that may accumulate on the leeward side due to drifting.

The slide load is the load that can slide from an upper roof onto a lower roof, or a lower part of a roof.

3.3 Partial loading due to melting, sliding, snow redistribution and snow removal

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 which are sensitive to the form of the load distribution (e.g. curved roofs, arches, domes or other structures).

4 Characteristic snow load on the ground

The characteristic snow load on the ground, s_0, is determined by statistical treatment of snow data.

Snow load measurements on the ground should be taken in a well-sheltered area.

Methods for the determination of the characteristic snow load on the ground, s_0, are described in annex A.

For practical application, the characteristic snow load on the ground will be defined in standard step values, which will yield basic values for the preparation of zone maps as described in annex A.

5 Snow load coefficients

5.1 Exposure coefficient

The exposure coefficient, C_e (see 2.7), depends on the topography, the intensity of winter wind, and the temperature.

Methods for the determination of C_e are given in annex B.

For regions where there are not sufficient winter climatological data available, it is recommended to set $C_e = 0{,}8$. However, the designer should always assess whether calm weather conditions (i.e. $C_e = 1{,}0$) during the snowfall season might yield more severe conditions for the structure.

5.2 Thermal coefficient

The thermal coefficient, C_t (see 2.8), is introduced to account for the reduction of snow load on roofs with high thermal transmittance, in particular glass-covered roofs, from melting caused by heat loss through the roof. For such cases C_t may take values less than unity. For all other cases, $C_t = 1{,}0$ applies.

Bases for the determination of C_t are the thermal transmittance of the roof, U, and the lowest temperature, θ , to be expected for the space under the roof, and the snow load on the ground, s_0.

NOTE The intensity of snowfall for short periods, approximately 1 to 5 days, is often a more relevant parameter than s_0 for roofs with considerable heat loss, since the melting is too rapid to allow accumulation throughout the winter. Since only s_0, however, is available, it has been used with the modifications given in annex D.

Methods for the determination of C_t for roofs with high thermal transmittance are described in annex D.

5.3 Surface material coefficient

The amount of snow which slides off the roof will, to some extent, depend on the surface material of the roofing; see 5.4.2.

The surface material coefficient, C_m (see 2.9), is defined to vary between unity and 1,333, and takes the fixed values:

$C_m = 1{,}333$ for slippery, unobstructed surfaces for which the thermal coefficient $C_t < 0{,}9$[1] (e.g. glass roofs);

$C_m = 1{,}2$ for slippery, unobstructed surfaces for which the thermal coefficient $C_t > 0{,}9$[1] (e.g. glass roofs over partially climatic conditioned space, metal roofs, etc.);

$C_m = 1{,}0$ corresponds to all other surfaces.

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[1] $C_m = 1{,}2$ could also be applied for $C_t < 0{,}9$ if this is assumed to be more reasonable.

5.4 Shape coefficients

5.4.1 General principles

The shape coefficients define distribution of the snow load over a cross-section of the building complex, and depend primarily on the geometrical properties of the roof.

For buildings of rectangular plan form, the distribution of the snow load in the direction parallel to the eaves is assumed to be uniform, corresponding to an assumed wind direction normal to the eaves.

The shape coefficients presented for selected types of roof are illustrated for one specific wind direction. Since prevailing wind directions may not correspond to the wind directions during heavy snow falls, all roofs should be designed for the condition that the wind during snow fall may have any direction with reference to the roof location.

For monopitch roofs and multispan roofs consisting of parallel monopitch roofs, a drift load part has been assumed to correspond to half the additional load on a pitched roof.

NOTE The subdivision of the shape coefficients into balanced load, drift load and slide load coefficients may not seem physically logical in all cases (e.g. multiple pitched roofs). However, the system has been applied for all roof shapes in view of the fact that the most unfavourable load conditions are taken care of by this subdivision.

Figures 1 to 4 are included to illustrate the function variations.

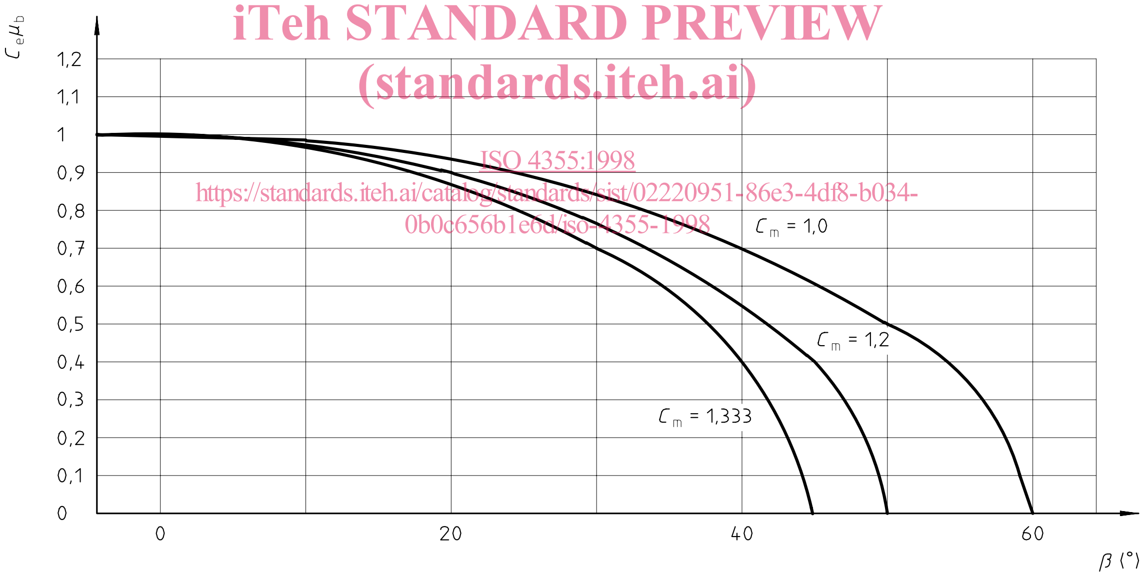


Figure 1 — $C_e\mu_b$ values for defined values of C_m with $C_e = 1,0$

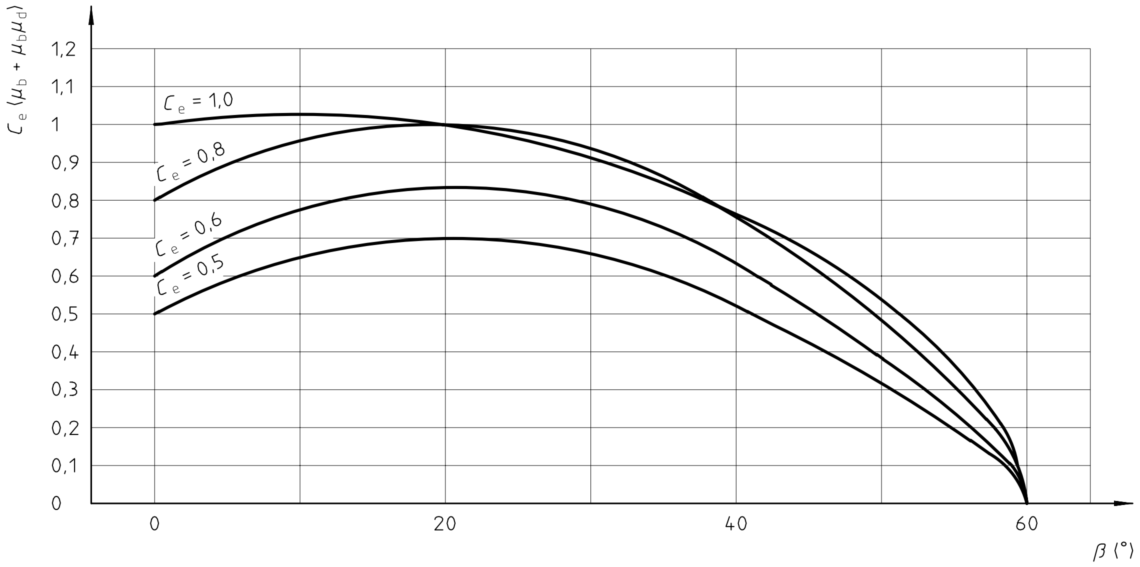
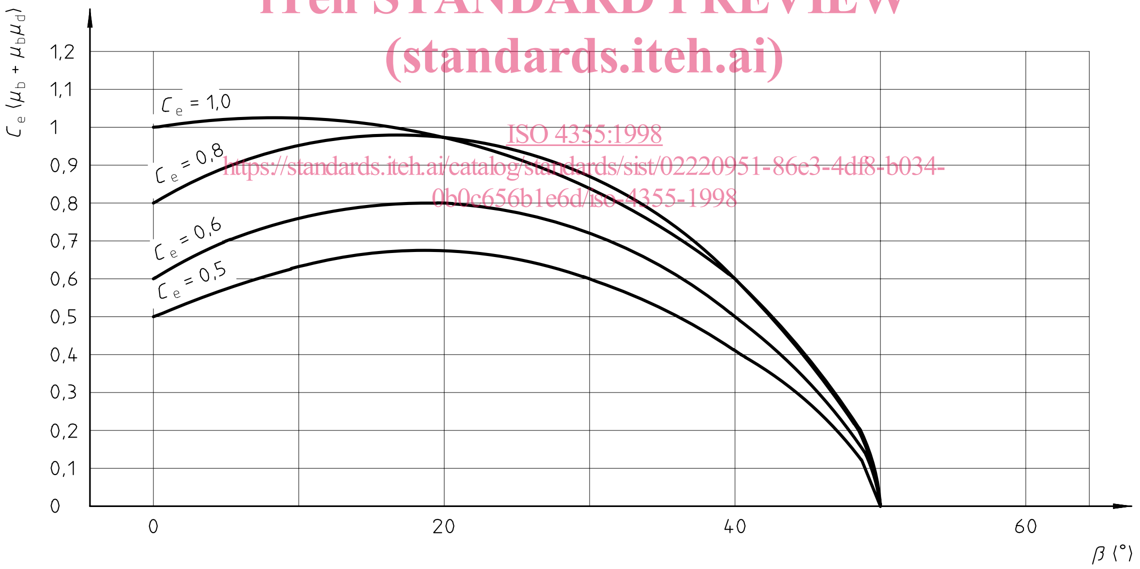


Figure 2 — $C_e(\mu_b + \mu_b \mu_d)$ **values for defined** C_e **values with** $C_m = 1{,}0$



$(\mu_b + \mu_b \mu_d)$ **values for defined** C_e **values with** $C_m = 1{,}2$

Figure 3 — C

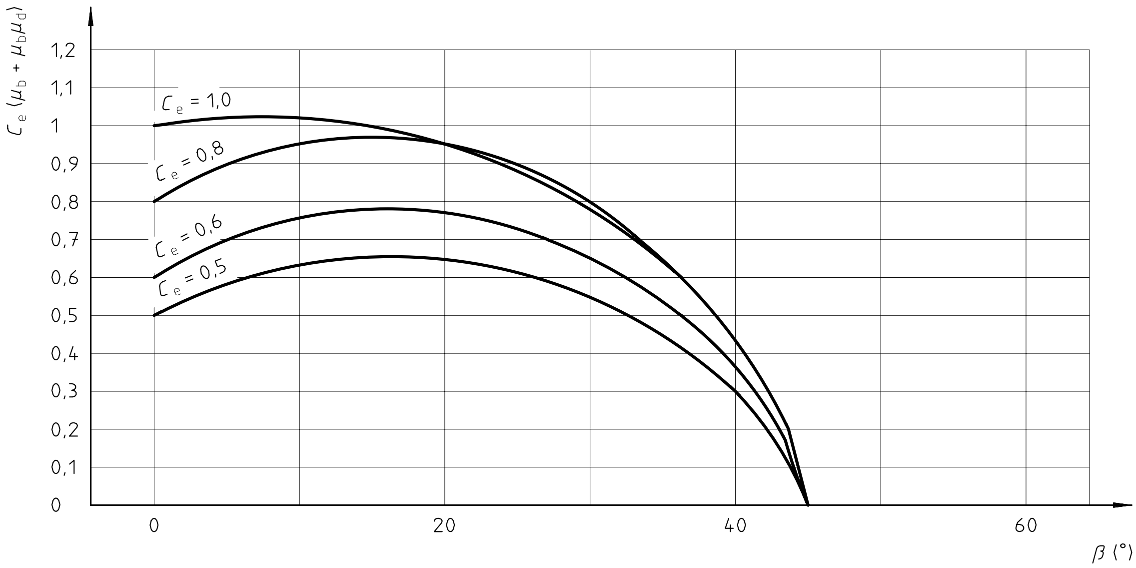


Figure 4 — $C_e(\mu_b + \mu_b\,\mu_d)$ values for defined C_e values with $C_m = 1{,}333$

5.4.2 Slope reduction coefficient

The reduction of the snow load on the roof due to the slope, β, of the roof and the surface material coefficient, C_m, is defined by the shape coefficient, μ_b (see 2.4), which is given by the function:

$$\mu_b = \sqrt{\cos(C_m\,1{,}5\,\beta)} \quad (\text{for } C_m\,1{,}5\,\beta < 90°) \qquad \text{.. (7)}$$

$$\mu_b = 0 \quad (\text{for } C_m\,1{,}5\,\beta \geqslant 90°)$$

For roofs with snow rails or obstructions preventing the snow from sliding off, $\mu_b = 1{,}0$. For multiple pitched roofs and inner bays of multispan roofs, sliding may lead to redistribution of the snow load.

5.4.3 Drift load coefficient

The geometrical influence of the shape on the drift load accumulating on the leeward side of a pitched roof is defined by the shape coefficient $\mu_b\,\mu_d$, which for a roof with roof angle β is defined by the function:

$$\mu_b\,\mu_d = \mu_b(2{,}2C_e - 2{,}1C_e^2)\,\sin(3\beta) \quad (\text{for } 0° \leqslant \beta \leqslant 60°) \qquad \text{... (8)}$$

$$\mu_b\,\mu_d = 0 \quad (\text{for } \beta > 60°)$$

Equation (8) includes the effects of loss of snow being blown away from the roof by wind, and is scaled to yield total loads corresponding to measured loads on ordinary pitched roofs.

NOTE The form of the drift load coefficient ensures that a certain drift load part must always be checked even for regions with very calm weather; i.e. $C_e = 1{,}0$.

5.4.4 Slide load coefficient

Slide load from an upper part of a roof onto a lower part of a roof, or onto a lower roof of a multilevel roof, will depend on the amount of snow that may slide down, and on the geometrical configuration of the roof.

The distribution of the slide load and the spreading out of the load will, in addition to the geometrical shape of the roof, depend on the properties of the sliding snow and on the friction on the upper roof from which the snow is sliding.

The slide load magnitude and distribution is incorporated in the shape coefficient μ_s.

An approximate slide load model is presented in 5.4.5.6, in which the slide load distribution is assumed to be linear, where it is assumed that 50 % of the maximum load on the upper roof will slide down (and that the coefficient of friction of the upper roof is zero) and that snow will slide from the top of the upper roof.

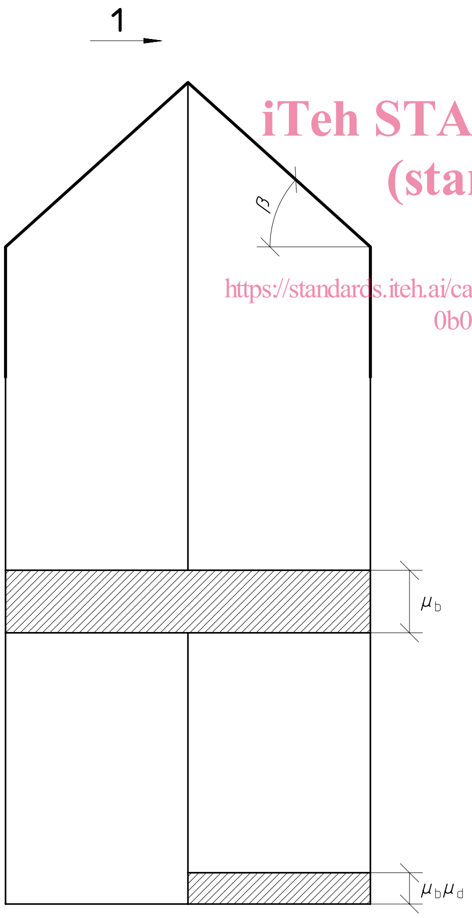
The impact loading on multilevel roofs due to slide load should be considered.

5.4.5 Snow load distribution on selected types of roof

NOTE A discussion of s_0 is given in clause 4, and C_e, C_t and C_m are discussed in 5.1, 5.2 and 5.3 respectively.

5.4.5.1 Simple pitched roofs (positive roof slope)

See figure 5. For asymmetrical simple pitched roofs, each side of the roof shall be treated as one-half of a corresponding symmetrical roof.



Windward side: $s = s_b$
Leeward side: $s = s_b + s_d$

Balanced load part

$$s_b = s_0 C_e C_t \mu_b$$

$$\mu_b = \sqrt{\cos(C_m 1{,}5\,\beta)} \quad (\text{for } C_m 1{,}5\,\beta \le 90°)$$

$$\mu_b = 0 \quad (\text{for } C_m 1{,}5\,\beta > 90°)$$

Drifted load part

$$s_d = s_0 C_e C_t (\mu_b \mu_d)$$

$$\mu_d = (2{,}2C_e - 2{,}1C_e^2) \sin(3\beta) \quad (\text{for } \beta \le 60°)$$

$$\mu_d = 0 \quad (\text{for } \beta > 60°)$$

Key
1 Wind direction

Figure 5 — Snow load distribution on a simple pitched roof