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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

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Contents

Page

Foreword iv

Introduction v

1 Scope 1

2 Normative references 1

3 Terms and definitions 1

4 Snow loads on roofs 3

4.1 General function describing intensity and distribution of the snow load on roofs 3

4.2 Approximate formats for the determination of the snow load on roofs 3

4.3 Partial loading due to melting, sliding, snow redistribution, and snow removal 4

4.4 Ponding instability 4

5 Characteristic snow load on the ground 4

6 Snow load coefficients 4

6.1 Exposure coefficient 4

6.2 Thermal coefficient 6

6.3 Surface material coefficient 6

6.4 Shape coefficients 6

Annex A (informative) **Background on the determination of some snow parameters** 8

Annex B (normative) **Snow load distribution on selected types of roof** 13

Annex C (informative) **Determination of the exposure coefficient for small roofs** 28

Annex D (informative) **Determination of thermal coefficient** 31

Annex E (informative) **Roof snow retention devices** 34

Annex F (informative) **Snow loads on roof with snow control** 36

Annex G (informative) **Alternative methods to determine snow loads on roofs not covered by the prescriptive methods in this International Standard** 38

Bibliography 39

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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 98, *Bases for design of structures*, Subcommittee SC 3, *Loads, forces and other actions*.

This third edition cancels and replaces the second edition (ISO 4355:1998), which has been technically revised.

Introduction

The intensity and distribution of snow load on roofs can 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 a function of the characteristic snow load on the ground, s_0, specified for the region considered, and a shape coefficient 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 can be redistributed as a result of wind action; melted water can flow into local areas and refreeze; snow can slide or can be removed.

In order to apply this International Standard, each country will have to establish maps and/or other information concerning the geographical distribution of snow load on ground 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 can 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 snow load on ground in the form of zone maps, tables, or formulae.

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

For determining the snow loads on roofs of unusual shapes or shapes not covered by this International Standard or in national standards, it is advised that special studies be undertaken. These can include testing of scale models in a wind tunnel or water flume, especially equipped for reproducing accumulation phenomena, and should include methods of accounting for the local meteorological statistics. Examples of numerical methods, scale model studies, and accompanying statistical analysis methods are described in Annex G.

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 can 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 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 2394[1)], *General principles on reliability for structures*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
characteristic value of snow load on the ground
s_0
load with a specified annual exceedance probability

Note 1 to entry: It is expressed in kilonewton per square metre (kN/m^2).

Note 2 to entry: In meteorology, the term “weight of the ground snow cover” is also used.

1) In process of revision.

3.2
shape coefficient
μ
coefficient which defines the amount and distribution of the snow load on the roof over a cross section of the building complex and primarily depends on the geometrical properties of the roof

3.3
value of snow load on roofs
s
function of the characteristic snow load on the ground, s_0, and appropriate shape coefficients

Note 1 to entry: The value of s is also dependent on the exposure of the roof and the thermal conditions of the building.

Note 2 to entry: It refers to a horizontal projection of the area of the roof.

Note 3 to entry: It is expressed in kilonewton per square metre (kN/m^2).

3.4
basic load 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, C_m

3.5
drift load coefficient
μ_d
coefficient which defines the amount and redistribution of additional load on a leeward side or part of a roof, depending on the exposure of the roof to wind, C_e, and the geometrical configurations of the roof

3.6
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

3.7
exposure coefficient
C_e
coefficient which accounts for the effects of the roof's exposure to wind

3.8
exposure coefficient for small roofs
C_{e0}
exposure coefficient for small roofs with effective roof length shorter than 50 m

3.9
effective roof length
l_c
length of the roof influenced by exposure coefficient given as a function of roof dimensions

3.10
thermal coefficient
C_t
coefficient defining the change in snow load on the roof as a function of the heat flux through the roof

Note 1 to entry: C_t, in some cases, can be greater than 1,0. Further guidance is given in 6.2 and Annex D.

3.11
surface material coefficient
C_m
coefficient defining a reduction of the snow load on sloped roofs made of surface materials with low surface roughness

3.12
equivalent snow density
ρ_e
density for calculating the annual maximum snow load from annual maximum snow depth

3.13
snow density
ρ
ratio between snow load and snow depth

4 Snow loads on roofs

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

Formally, the snow load on roofs can be defined as a function, F, of several parameters:

$$s = F\left(s_0, C_e, C_t, C_m, \mu_b, \mu_d, \mu_s\right) \quad (1)$$

where the symbols are as defined in Clause 3.

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 generally vary throughout the roof.

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

This International Standard defines the snow load on the roof as a combination of a basic load part, 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):

$$s = s_b \text{ "+" } s_d \text{ "+" } s_s \quad (2)$$

where "+" implies "to be combined with".

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

$$s_b = 0{,}8 s_0 C_e C_t \mu_b \quad (3)$$

$$s_d = s_0 \mu_b \mu_d \quad (4)$$

$$s_s = s_0 \mu_s \quad (5)$$

The basic roof snow load, s_b, is uniformly distributed in all cases, [1] [2] except for curved roofs, where the distribution varies with the slope, β (see B.4).

The basic load defines the load on a horizontal roof, and the load on the windward side of a pitched roof. Since any direction can be the wind direction, the basic 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 can 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.

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

A load 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 particularly important for structures which are sensitive to unbalanced loading (e.g. curved roofs, arches, domes, collar beam roofs, continuous beam systems) which are addressed in other clauses of this International Standard.

4.4 Ponding instability

Roofs shall be designed to preclude ponding instability. For flat roofs (or with a small slope), roof deflections caused by snow loads shall be investigated when determining the likelihood of ponding instability from rain-on-snow or from snow meltwater.

5 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 an undisturbed area not subject to localized drifting.

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.

6 Snow load coefficients

6.1 Exposure coefficient

The exposure coefficient, C_e, should be used for determining the snow load on the roof. The choice of C_e should consider the future development around the site. For regions where there are no sufficient winter climatological data available, it is recommended to set C_e = 1,0.

For most cases, the exposure coefficient, C_e, is equal to the exposure coefficient for small roofs, C_{e0}. However, for very large flat roofs, wind is less effective in removing snow from the whole roof. To compensate for this, the exposure coefficient for large roofs is higher than for smaller roofs.

$$C_e = \begin{cases} C_{e0} & l_c \le 50\text{ m} \\ 1{,}25 - (1{,}25 - C_{e0})\, e^{-(l_c - 50)/200} & l_c > 50\text{ m} \end{cases} \quad (6)$$

where

l_c is the effective roof length equal to $2W - \frac{W^2}{L}$ in metres;

C_{e0} is the exposure coefficient for small roofs.

Methods for the determination of C_{e0} are given in Annex C.

In the expression for l_c, W is the length of the shorter side of the roof and L is the length of the longer side (see Figure 1).

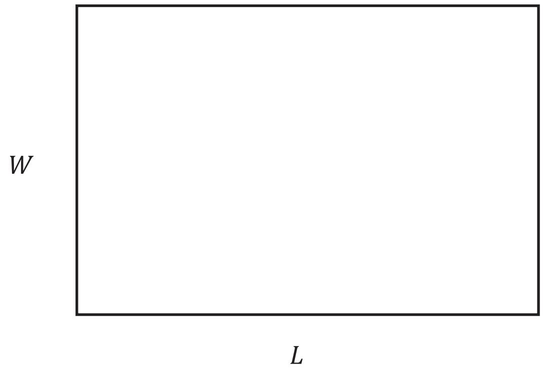

Figure 1 — Rectangular roof dimensions

For non-rectangular roofs, W and L can be taken as the shorter and longer side of the roof's major dimensions along two orthogonal axes. For example, for an elliptical shape, W is measured along the short axis and L along the long axis.

An overview of the exposure coefficient is shown in Figure 2.

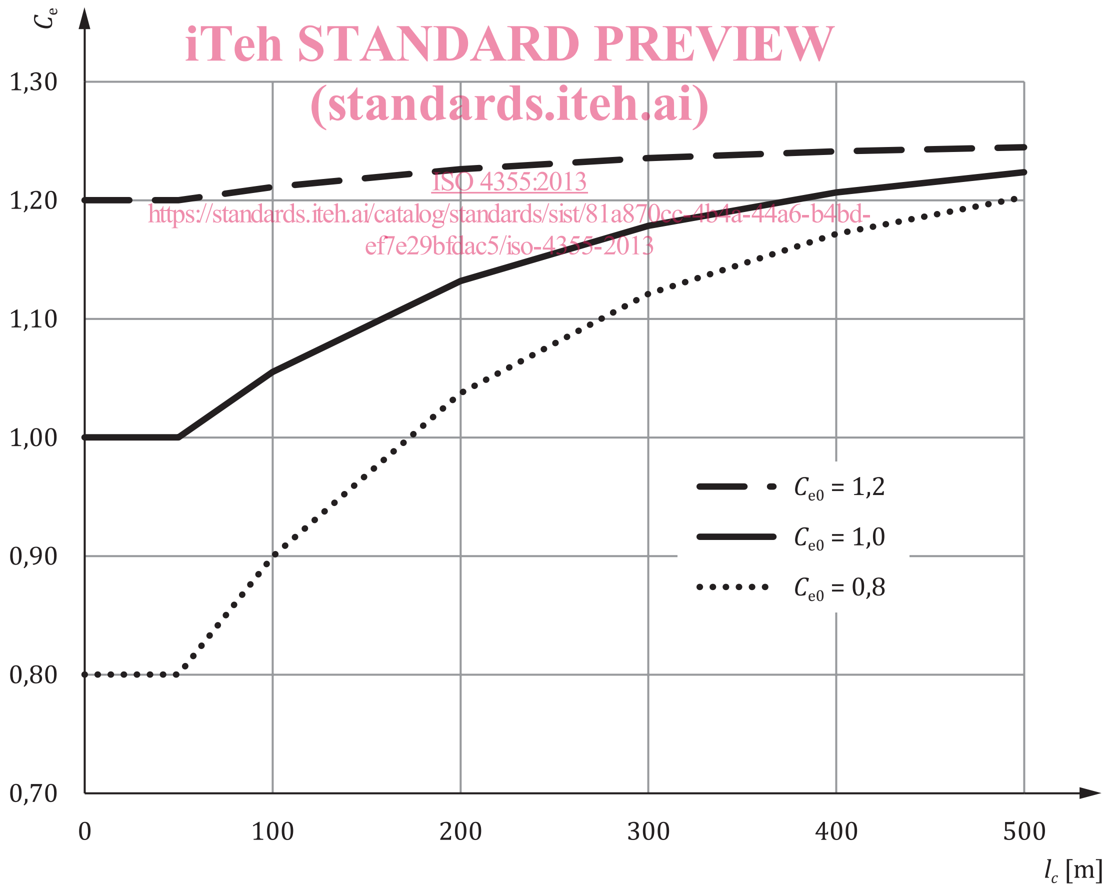

Figure 2 — Exposure coefficient, C_e, as a function of effective roof length, l_c

6.2 Thermal coefficient

The thermal coefficient, C_t (see 3.10), is introduced to account for effect of thermal transmittance of the roof.

The snow load is reduced on roofs with high thermal transmittance because of melting caused by heat loss through the roof. For such cases and for glass-covered roofs in particular, C_t, can take values less than unity.

For buildings where the internal temperature is intentionally kept below 0 °C (e.g. freezer buildings, ice skating arenas), C_t, can be taken as 1,2. 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.

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

NOTE The intensity of snowfall for short periods, approximately 1 d to 5 d, 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.

6.3 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 6.4.2.

The surface material coefficient, C_m (see 3.11), is defined to vary between unity and 1,333, and takes the following fixed values:

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

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

— C_m = 1,0 corresponds to all other surfaces.

NOTE C_m = 1,2 could also be applied for C_t <0,9 if this is assumed to be more reasonable.

6.4 Shape coefficients

6.4.1 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 (see Annex B), are illustrated for one specific wind direction. Since prevailing wind directions can not correspond to the wind directions during heavy snow falls, the condition that the wind during snow fall can have any direction with reference to the roof location should be considered when designing roofs.

6.4.2 Basic load coefficient

When snow on sloped roofs can slide off unobstructed, snow load on the roof will be reduced. 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 3.4), which is given by Formula (7):

$$\mu_b = \begin{cases} 1 & \beta < 30(1/C_m) \\ (60 - C_m\beta)/30 & 30(1/C_m) < \beta < 60(1/C_m) \\ 0 & \beta > 60(1/C_m) \end{cases} \quad (7)$$

An overview of the basic load coefficient is shown in Figure 3.

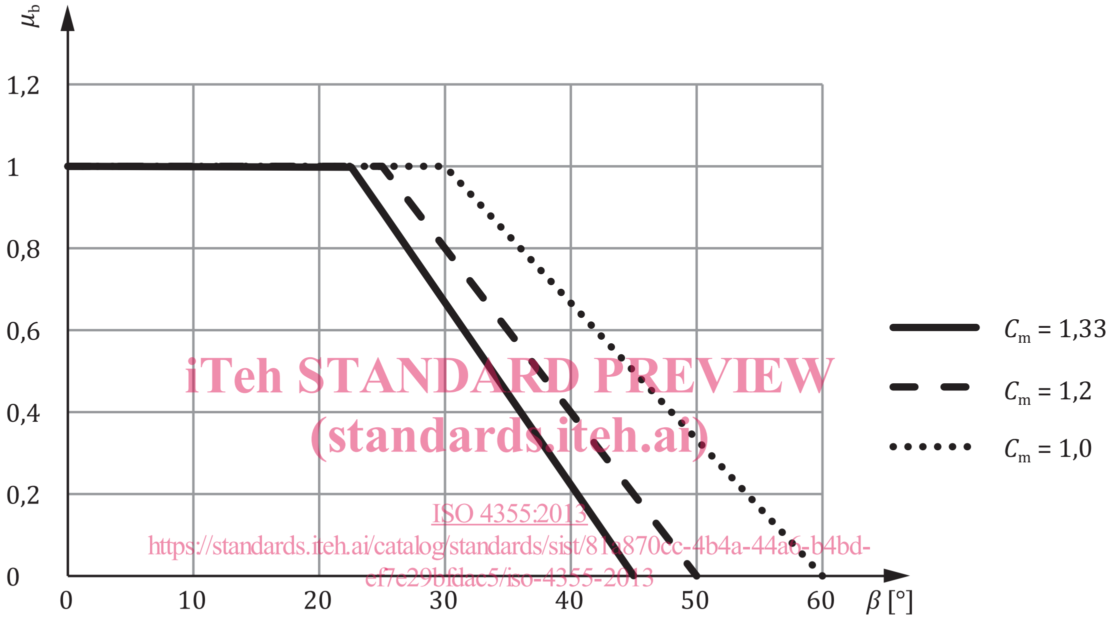

Figure 3 — Basic load coefficient, μ_b, as a function of surface material coefficient, C_m

6.4.3 Drift load coefficient

The drift load coefficient, μ_d (see 3.5), is dependent on the roof geometry and the exposure coefficient, C_e, and is described in Annex B.

6.4.4 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 can 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 slide load coefficient, μ_s (see 3.6).

In the cases when slide load should be considered, the slide load coefficient for different roof types is described in Annex B.

The impact loading due to slide load should be considered.

