

Eurocode 1: Basis of design and actions on structures —

Part 2.3: Actions on structures — Snow loads

ICS 91.040

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Committees responsible for this Draft for Development

The preparation of this Draft for Development was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/1, Actions (loadings) and basis of design, upon which the following bodies were represented:

- British Constructional Steelwork Association
- British Iron and Steel Producers' Association
- British Masonry Society
- Concrete Society
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Property and Buildings Directorate)
- Highways Agency
- Institution of Structural Engineers
- National House-building Council
- Royal Institute of British Architects
- Steel Construction Institute

This Draft for Development, having been prepared under the direction of the Sector Board for Building and Civil Engineering, was published under the authority of the Standards Board and comes into effect on 15 April 1996

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The following BSI reference relates to the work on this Draft for Development:
Committee reference B/525/1

ISBN 0 580 25713 4

Amendments issued since publication

Amd. No.	Date	Comments

Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Foreword	2
Text of ENV 1991-2-3	5

National foreword

This Draft for Development has been prepared by Subcommittee B/525/1 and is the English language version of ENV 1991-2-3 *Eurocode 1: Basis of design and actions on structures — Part 2-3: Actions on structures — Snow loads* published by the European Committee for Standardization (CEN).

ENV 1991-2-3 results from a programme of work sponsored by the European Commission to make available a common set of rules for the design of building and civil engineering works.

The full range of codes covers the basis of design and actions, the design of structures in concrete, steel, composite construction, timber, masonry and aluminium alloy, and geotechnical and seismic design.

This publication is not to be regarded as a British Standard.

An ENV or European Prestandard is made available for provisional application but it does not have the status of a European Standard. The aim is to use the experience gained to modify the ENV so that it can be adopted as a European Standard (EN).

During the drafting of ENV 1991-2-3, the CEN Project Team accepted arguments from the UK that this country has different climatic conditions to mainland Europe. Annex B was introduced into the draft to include some of BS 6399-3. The BSI Technical Committee responsible for the UK loading code has more recently reviewed the content of BS 6399-3 and is to amend the British Standard in response to particular problems. It would be inappropriate for superseded information to be presented in the ENV document and a National Application Document would have to make extensive reference to the amended British Standard. The resulting DD ENV would not be considered a practical document for use in the design office.

Consequently, ENV 1991-2-3 is not to be used in the UK for design purposes. For snow loads, the designer should consult BS 6399-3. This situation will change when European Prestandards are converted to full European Standards and it is important that the UK generates full and effective comments on the ENV document to ensure a satisfactory conversion.

The reasons for publishing DD ENV 1991-2-3 in the UK are:

- a) for informative purposes, to enable structural designers in the UK to familiarize themselves with the contents of ENV 1991-2-3;
- b) to enable full and effective UK comments on ENV 1991-2-3 to be obtained during its ENV period, so that these can be considered during the preparation of the EN.

Feedback on this document is therefore encouraged and comments are invited on its technical content, ease of use and ambiguities or anomalies. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted to an EN.

Comments should be sent in writing to the Secretary of Subcommittee B/525/1 at BSI, 389 Chiswick High Road, London W4 4AL quoting the document reference, the relevant clause and, where possible, a proposed revision by the end of June 1997. Comments after this time will still be possible through corporate bodies, such as the engineering institutions.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the ENV title page, pages 2 to 46 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

ICS 91.040.00

Descriptors: Buildings, structures, design, computation, loads:forces, weather effects, weather resistances, snow

English version

**Eurocode 1 —
Basis of design and actions on structures —
Part 2-3: Actions on structures — Snow loads**

Eurocode 1 — Bases du calcul et actions sur les
structures — Partie 2-3: Actions sur les
structures — Charges de neige

Eurocode 1 — Grundlagen der
Tragwerksplanung und Einwirkungen auf
Tragwerke — Teil 2-3: Einwirkungen auf
Tragwerke — Schneelasten

This European Prestandard was approved by CEN on 1993-06-30 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into an European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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Foreword

Objectives of the Eurocodes

- 1) The “Structural Eurocodes” comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.
- 2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship, needed to comply with the assumptions of the design rules.
- 3) Until the necessary set of harmonised technical specifications for products and for methods of testing their performance are available, some of the Structural Eurocodes cover some of these aspects in informative Annexes.

Background to the Eurocode Programme

- 4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building and civil engineering works which would initially serve as an alternative to the different rules in force in the various Member States and would ultimately replace them. These technical rules became known as the “Structural Eurocodes”.
- 5) In 1990, after consulting their respective Member States, the CEC transferred the work of further development, issue and updating of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.
- 6) CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode Programme

- 7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of parts:

EN 1991, *Eurocode 1: Basis of design and actions on structures.*

EN 1992, *Eurocode 2: Design of concrete structures.*

EN 1993, *Eurocode 3: Design of steel structures.*

EN 1994, *Eurocode 4: Design of composite steel and concrete structures.*

EN 1995, *Eurocode 5: Design of timber structures.*

EN 1996, *Eurocode 6: Design of masonry structures.*

EN 1997, *Eurocode 7: Geotechnical design.*

EN 1998, *Eurocode 8: Design of structures for earthquake resistance.*

EN 1999, *Eurocode 9: Design of aluminium alloy structures.*

- 8) Separate sub-committees have been formed by CEN/TC250 for the various Eurocodes listed above.
- 9) This part of Eurocode 1 is being published as a European Prestandard (ENV) with an initial life of three years.
- 10) This Prestandard is intended for experimental application and for the submission of comments
- 11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.
- 12) Meanwhile feedback and comments on this Prestandard should be sent to the Secretariat of CEN/TC250/SC1 at the following addresses:

SNV/SIA (until end
May 1995)

Selnaustrasse 16
CH-8039 ZURICH
SWITZERLAND

SIS/BST (from
June 1995)

Box 5630
S- 114 86 Stockholm
SWEDEN

or to your national standards organisation.

National Application Documents (NAD's)

- 13) In view of the responsibilities of authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by [] (“boxed values”). The authorities in each member country are expected to review the “boxed values” and may substitute alternative definitive values for these safety elements for use in national application.

- 14) Some of the supporting European or International Standards may not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving any substitute definitive values for safety elements, referencing compatible supporting standards and providing guidance on the national application of this Prestandard, will be issued by each member country or its Standards Organization.

- 15) It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works is located.

Matters specific to this Prestandard

16) The scope of Eurocode 1 is defined in clause 1.1.1 and the scope of this Part of Eurocode 1 is defined in 1.1.2. Additional parts of Eurocode 1 which are planned are indicated in clause 1.1.3.

17) This Part is complemented by a number of annexes, some normative and some informative. The normative annexes have the same status as the sections to which they relate.

18) The characteristic value of the snow load on the ground shall be provided in the form of maps or otherwise (see Annex A) by the competent authority. The value provided for characteristic loads shall conform with the definitions given in ENV 1991-1 clause 4.2. In the cases where the value of the snow load on the ground is not consistent with the definition of the characteristic value, the NAD should state the corresponding value.

19) In the particular case considered in section 2 where the snow load can be treated as an accidental action, the NAD should provide guidance for the treatment of the action in design.

20) Allowance shall be made in the NAD for local effects which are unlikely to have been considered in the statistical analysis for national loads. Particularly important are effects due to local topography and diversion of the wind.

21) Where there is doubt about the validity of the recommended snow loads, the procedure to consult the competent authority should be given in the NAD.

Contents

	Page
Foreword	2
Objectives of the Eurocodes	2
Background to the Eurocode Programme	2
Eurocode Programme	2
National Application Documents (NAD's)	2
Matters Specific to this Prestandard	3
Section 1. General	5
1.1 Scope	5
1.1.1 Scope of ENV 1991-Eurocode 1	5
1.1.2 Scope of ENV 1991-2-3 Snow loads	5
1.1.3 Further Parts of ENV 1991	5
1.2 Normative references	5
1.3 Distinction between principles and application rules	6
1.4 Definitions	6
1.5 Symbols	6
Section 2. Classification of actions	7
Section 3. Design situations	7
Section 4. Representation of action	7
4.1 Nature of the load	7
4.2 Modelling of the load	7
Section 5. Load arrangements	7
5.1 Snow load on roofs	7
5.2 Snow overhanging the edge of a roof	8
5.3 Snow loads on snowguards and obstacles	8
5.4 Snow loads on bridges	9
Section 6. Snow load on the ground — characteristic values	9
Section 7. Snow load shape coefficients	9
7.1 General	9
7.2 Pitched roofs	9
7.3 Cylindrical roofs	12
7.4 Abrupt changes of roof heights	13
7.5 Drifting at projections and obstructions	14
Annex A (informative) Characteristic values of snow load on ground	15
Annex B (normative) Snow load shape coefficients for specific climatic regions	43
Annex C (informative) Adjustment of the return period of ground snow load	45
Annex D (informative) Bulk weight density of snow	46

	Page		Page
Figure 5.1 — Snow overhanging the edge of a roof	8	Table A.1 — Snow loads on the ground for Norwegian municipalities (Norwegian Standard NS 3479: Tillegg C)	30
Figure 7.1 — Snow load shape coefficients — pitched roofs	10	Table A.15.1 — Spain — Snow loads on the ground depending on the Snow zone and the altitude	36
Figure 7.2 — Snow load shape coefficient — monopitch roof	10	Table A.2	37
Figure 7.3 — Snow load shape coefficients — duopitched roofs	11	Table 1 — Mean bulk weight density of snow	46
Figure 7.4 — Snow load shape coefficients — multipitch roofs	11		
Figure 7.5 — Snow load shape coefficients — cylindrical roof	12		
Figure 7.6 — Snow load shape coefficients for cylindrical roofs of differing rise to span ratios	12		
Figure 7.7 — Snow load shape coefficients — abrupt change of roof height	13		
Figure 7.8 — Snow load shape coefficients at projections and obstructions	14		
Figure A.1 — Austria — snow zones	16		
Figure A.2 — Finland — Characteristic snow load on the ground	18		
Figure A.3 — France — snow zones	20		
Figure A.4 — Germany — Snow zones	22		
Figure A.5 — Greece — Snow zones	24		
Figure A.6 — Iceland — Snow zones	26		
Figure A.7 — Italy — Snow zones	28		
Figure A.15.1 — Spain — Snow zones	37		
Figure A.8 — Sweden — Snow zones	38		
Figure A.9 — Switzerland — Altitudes	40		
Figure A.10 — Ireland & United Kingdom: — Basic snow load on the ground	42		
Figure B.1 — Drift length and snow load shape coefficient — multi-pitch roof	43		
Figure B.2 — Drift length and snow load shape coefficient for local drift at abrupt change of roof height	44		
Figure B.3 — Snow load shape coefficients — drifts at obstructions	45		
Table 7.1 — Snow load shape coefficient — monopitch roofs	10		
Table 7.2 — Snow load shape coefficient — duopitch roofs	11		
Table 7.3 — Snow load shape coefficients — multipitch roofs	11		

Section 1. General

1.1 Scope

1.1.1 Scope of ENV 1991 — Eurocode 1

- 1) P ENV 1991 provides general principles and actions for the structural design of buildings and civil engineering works including some geotechnical aspects and shall be used in conjunction with ENV 1992–1999.
- 2) It may also be used as a basis for the design of structures not covered in ENV 1992–1999 and where other materials or other structural design actions are involved.
- 3) ENV 1991 also covers structural design during execution and structural design for temporary structures. It relates to all circumstances in which a structure is required to give adequate performance.
- 4) ENV 1991 is not directly intended for the structural appraisal of existing construction, in developing the design of repairs and alterations or, for assessing changes of use.
- 5) ENV 1991 does not completely cover special design situations which require unusual reliability considerations such as nuclear structures for which specified design procedures should be used.

1.1.2 Scope of ENV 1991-2-3 Snow loads

- 1) P Design guidance is provided for loads imposed by snow which has fallen in calm air and in windy conditions for the structural design of buildings and civil engineering work.
- 2) P This Part does not generally apply for sites at altitudes above 1 500 m.
- 3) Annex B may be used in specific regions where all the snow normally melts and clears between individual weather systems and wind speeds are high.

NOTE Use of Annex B has to be agreed with the National Competent Authority.

- 4) This Part does not give guidance on:
 - impact snow loads resulting from snow sliding off or falling from a higher roof;
 - loads which could occur if snow and ice block drainage systems;
 - the additional wind loads which could result from changes in shape or size of the building structure due to the presence of snow or the accretion of ice;
 - loads in areas where snow is present all the year;
 - ice loading;
 - lateral loading due to snow (e.g. lateral loads exerted by drifts);
 - the increase in load due to heavy rain falling on snow.
- 5) ENV 1991-2-3 shall be used only in conjunction with ENV 1991-1 and other Parts of ENV 1991.

1.1.3 Further Parts of ENV 1991

- 1) Further Parts of ENV 1991 which, at present, are being prepared or are planned are given in 1.2.

1.2 Normative references

This European Prestandard incorporates by dated or undated reference, provisions from other standards. These normative references are cited in the appropriate places in the text and publications listed hereafter. ISO 3898 1987, *Basis of design for structures — Notations. General symbols.*

NOTE The following European Prestandards which are published or in preparation are cited at the appropriate places in the text and publications listed hereafter.

ENV 1991-1, *Eurocode 1: Basis of design and actions on structures — Part 1: Basis of design.*

ENV 1991-2-1, *Eurocode 1: Basis of design and actions on structures — Part 2.1: Densities, self-weight and imposed loads.*

ENV 1991-2-2, *Eurocode 1: Basis of design and actions on structures — Part 2.2: Actions on structures exposed to fire.*

ENV 1991-2-4, *Eurocode 1: Basis of design and actions on structures — Part 2.4: Wind loads.*

ENV 1991-2-5, *Eurocode 1: Basis of design and actions on structures — Part 2.5: Thermal actions.*

ENV 1991-2-6, *Eurocode 1: Basis of design and actions on structures — Part 2.6: Loads and Deformations imposed during execution.*

ENV 1991-2-7, *Eurocode 1: Basis of design and actions on structures — Part 2.7: Accidental actions.*

ENV 1991-3, *Eurocode 1: Basis of design and actions on structures — Part 3: Traffic loads on bridges.*

ENV 1991-4, *Eurocode 1: Basis of design and actions on structures — Part 4: Actions in silos and tanks.*

ENV 1991-5, *Eurocode 1: Basis of design and action on structures — Part 5: Actions induced by cranes and machinery.*

ENV 1992, *Eurocode 2: Design of concrete structures.*

ENV 1993, *Eurocode 3: Design of steel structures.*

ENV 1994, *Eurocode 4: Design of composite steel and concrete structures.*

ENV 1995, *Eurocode 5: Design of timber structures.*

ENV 1996, *Eurocode 6: Design of masonry structures.*

ENV 1997, *Eurocode 7: Geotechnical design.*

ENV 1998, *Eurocode 8: Earthquake resistant design of structures.*

ENV 1999, *Eurocode 9: Design of aluminium alloy structures.*

1.3 Distinction between principles and application rules

- 1) Depending on the character of the individual clauses, distinction is made in this part between principles and application rules.
- 2) The principles comprise:
 - general statements and definitions for which there is no alternative, as well as
 - requirements and analytical models for which no alternative is permitted unless specifically stated.
- 3) The principles are identified by the letter P following the paragraph number.
- 4) The application rules are generally recognized rules which follow the principles and satisfy their requirements.
- 5) It is permissible to use alternative rules different from the application rules given in this Eurocode, provided it is shown that the alternative rules accord with the relevant principles and have at least the same reliability.
- 6) In this Part the application rules are identified by a number in brackets e.g. as this clause.

1.4 Definitions

- 1) For the purposes of this prestandard, a basic list of definitions is provided in ENV 1991-1, “*Basis of design*”.

1.5 Symbols

- 1) For the purpose of this Prestandard, the following symbols apply.

NOTE The notation used is based on ISO 3898:1987

- 2) A basic list of notations is provided in ENV 1991-1, “*Basis of design*” and the additional notations below are specific to this Part.

Latin upper case letters

C_e	exposure coefficient
C_t	thermal coefficient

Latin lower case letters

F_s	force exerted by a sliding mass of snow
b	width
h	height
k	coefficient to take account of the irregular shape of snow
l_s	length of snow drift
s	snow load on the roof
s_k	characteristic value of snow on the ground
s_e	snow load per metre width due to overhang

Greek Lower case letters

α	pitch of roof, measured from horizontal [°]
β	angle between the horizontal and the tangent to the curve for a cylindrical roof
γ	weight density of snow
μ	snow load shape coefficient

Section 2. Classification of actions

- 1) P Snow loads are classified as variable free actions, see ENV 1991-1.
- 2) In particular cases, snow load can be treated as an accidental action. For the specific climatic regions to which 6.2 applies, the local drifting of snow on roofs is considered to form exceptional snow loads because of the rarity with which they occur and are treated as accidental loads in accordance with ENV 1991-1.

Section 3. Design situations

- 1) P The relevant snow loads shall be determined for each design situation identified, in accordance with ENV 1991-1.
- 2) P For roofed bridges, the snow loads and traffic loads shall be considered to occur simultaneously. Additional guidance is given in ENV 1991-3, Annexes C, D and H.
- 3) For bridges other than roofed bridges, the snow loads and traffic loads may not be generally considered as simultaneous.

Section 4. Representation of actions**4.1 Nature of the load**

- 1) Snow can be deposited on a roof in many different patterns depending on the shape of the roof, its thermal properties, the roughness of its surface, the amount of heat generated under the roof, the proximity of nearby buildings, the surrounding terrain and the local meteorological climate; in particular its windiness, temperature variations, and likelihood of precipitation (either as rain or as snow). Furthermore the deposits of snow can be due to an accumulation of snow from different directions or to one or more falls of snow within an individual weather system.

4.2 Modelling of the load

- 1) For assessment of snow load it is usual to consider primarily the uniform snow which has accumulated under calm air conditions, the shape of the roof and the snow pattern caused by windy conditions.

Section 5. Load arrangements**5.1 Snow load on roofs**

- 1) P The snow loads on a roof shall be determined from:

$$s = \mu_i C_e C_t s_k \quad (5.1)$$

where:

- μ_i is the snow load shape coefficient (see section 7)
- s_k is the characteristic value of the snow load on the ground [kN/m²] (see section 6)
- C_e is the exposure coefficient, which usually has the value 1,0
- C_t is the thermal coefficient, which usually has the value 1,0

- 2) P The load shall be assumed to act vertically and shall refer to a horizontal projection of the area of the roof.
- 3) P Loads according to this Part have been derived for natural deposition patterns and do not account for local imbalances due to artificial removal or redistribution of snow on a roof. In such cases suitable load arrangements shall be considered.

4) The snow load shape coefficients are defined in section 7 assuming the exposure coefficient is equal to 1,0. A reduction in the snow load on the roof may be permitted by the introduction of values of exposure coefficient less than 1,0, to take account of the effect of more severe wind conditions.

5) For normal standards of thermal insulation the thermal coefficient is assumed to be equal to 1,0. A reduction in the snow load on the roof may be permitted by the introduction of values of thermal coefficient less than 1,0, to take account of the effect of heat loss through the roof.

5.2 Snow overhanging the edge of a roof

1) P The design of those parts of a roof cantilevered out beyond the walls shall take account of snow overhanging the edge of the roof, in addition to the load on that part of the roof. The loads due to the overhang shall be assumed to act at the edge of the roof and shall be calculated as follows:

$$s_e = k \mu_i^2 s_k^2 / \gamma \quad (5.2)$$

where:

s_e is the snow load per metre width due to the overhang, [kN/m]

μ_i is the snow load shape coefficient appropriate to the roof

s_k is the snow load on the ground, [kN/m²]

k is a coefficient to take account of the irregular shape of the snow, and will be within the range 0,0 to 2,5 depending on climate and roofing material.

γ is the weight density of snow which for this calculation may be taken as 3 kN/m³

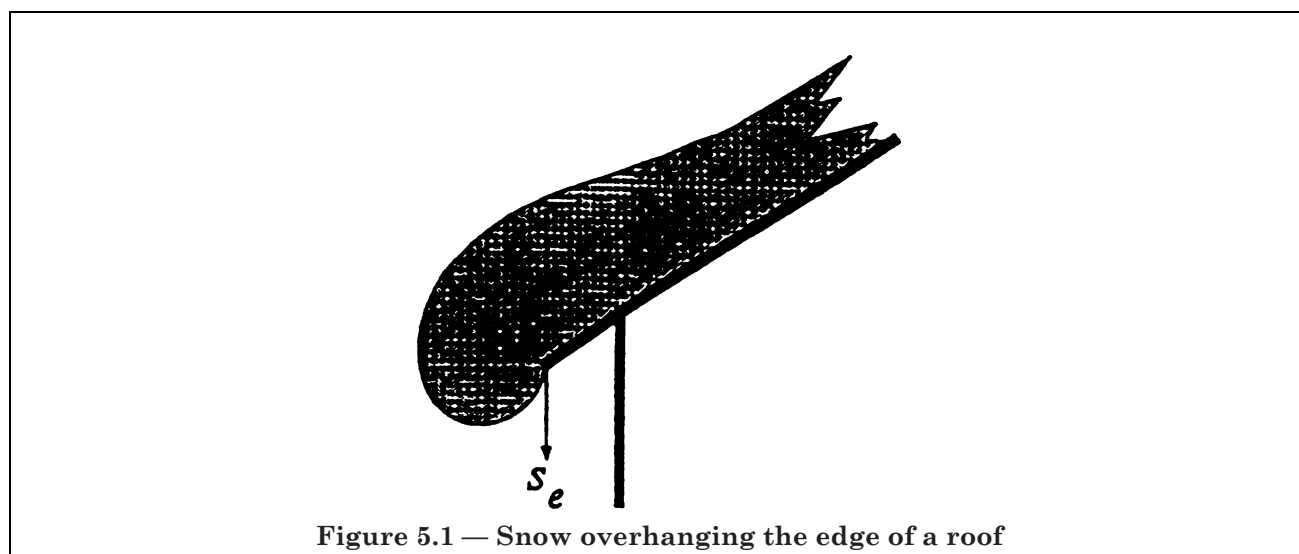


Figure 5.1 — Snow overhanging the edge of a roof

5.3 Snow loads on snowguards and obstacles

1) P The coefficient of friction between the snow and the roof shall be zero. Thus the force F_s exerted by a sliding mass of snow, in the direction of slide, per unit width shall be:

$$F_s = s b \sin \alpha \quad (5.3)$$

where:

$s = \mu_i s_k$ the snow load on the roof [kN/m²];

b is the distance on plan from the guard or obstacle to the ridge [m];

α pitch of the roof, measured from the horizontal [°].

μ is the snow load shape coefficient to the appropriate roof

2) P The snow load on the roof shall be obtained from 5.1 1) P and shall correspond to the most unfavourable distributed snow load.

5.4 Snow loads on bridges

- 1) P For roofed bridges, the snow loads shall be determined by the same procedure used for buildings.
- 2) For mechanically-moveable bridges a non-symmetrical distribution should be defined in the project specifications.
- 3) P When justified by climatic conditions and by the duration of the erection process, the snow load for the verification of static equilibrium during erection shall be considered as composed of a non-symmetrical distribution of snow located in the most unfavourable position. For this verification the snow loads shall be assumed to be [25 %] of the characteristic snow load on the ground.

Section 6. Snow load on the ground — characteristic values

1) The characteristic values of the snow load on the ground to be used in design for each of the CEN member states is given in Annex A. Altitude, return period and other correction factors are given in Annex A and should be applied where appropriate.

NOTE The snow load on the ground depends on the geographical location and the altitude of the site being considered. The characteristic value of the snow load on the ground is based on an annual probability of exceedance of 0,02, and should be determined from national snow load data.

In special cases the characteristic value of the snow load on the ground, s_k , 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, records for periods of less than 20 years will not generally be suitable. The statistical analysis should result in a characteristic snow load conforming with 1). However, for some climatic regions it may be more appropriate to take as the characteristic value a value defined by the Competent Authority.

2) In particular regions, snow load records show individual, extreme values which cannot be treated by the usual statistical methods used to evaluate the characteristic value determined according to 6 1). For these regions the extreme values may be considered as accidental loads.

Section 7. Snow load shape coefficients

7.1 General

1) P In general the snow load shape coefficients given in this clause shall be used. However, depending on a regions climatic conditions the snow load shape coefficient given in Annex B may be used. The indicated values of the snow load shape coefficients are nominal values.

2) In general three primary loading arrangements can be identified and are accounted for in the coefficients in 7.2:

- that resulting from a uniformly distributed layer of snow over the complete roof, likely to occur when snow falls with little wind;
- that resulting from either an initially unbalanced distribution, local drifting at obstructions, or a redistribution of snow which affects the load distribution on the complete roof, eg snow transported from the windward slope of a pitched roof to the leeward slope (due to drifting);
- that resulting from a redistribution of snow from an upper part of the building (due to sliding).

7.2 Pitched roofs

1) The values of the snow load shape coefficients for the roofs detailed in this clause are summarised in Figure 7.1

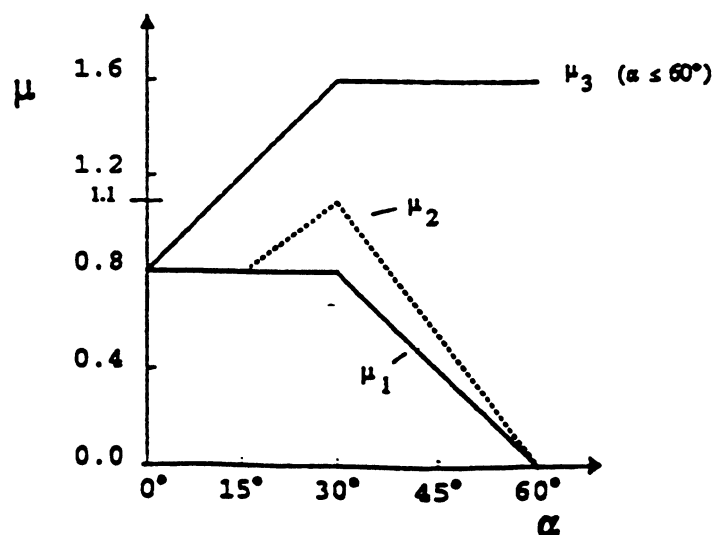


Figure 7.1 — Snow load shape coefficients — pitched roofs

Monopitch roofs

2) P The snow load shape coefficients for monopitch roofs are given in Table 7.1. It is assumed that the snow is not prevented from sliding off the roof. If the lower edge of the roof is terminated with a parapet, snow fence, or other obstruction then the snow load shape coefficient shall not be reduced below 0,8.

3) Two arrangements should be considered

- the uniform load arrangement [Figure 7.2(i)]
- the load arrangement consisting of half of the load intensity, acting over the most unfavourable half of the roof [Figure 7.2(ii)]

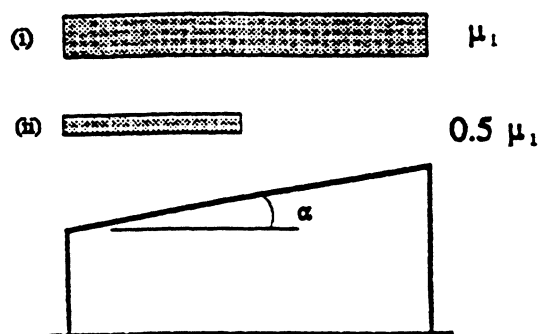


Figure 7.2 — Snow load shape coefficient — monopitch roof

Table 7.1 — Snow load shape coefficient — monopitch roofs

Angle of pitch of roof	$0^\circ \leq \alpha \leq 30^\circ$	$30^\circ < \alpha < 60^\circ$	$\alpha \geq 60^\circ$
Shape coefficient μ_1	0,8	$0,8(60 - \alpha)/30$	0,0

Duo pitched roofs

5) P The snow load shape coefficients for duopitch roofs are given in Table 7.2. It is assumed that the snow is not prevented from sliding off the roof. If an edge of the roof is terminated by a parapet, snow fence or other obstruction then the snow load shape coefficient for that side of the roof shall not be reduced below 0,8.

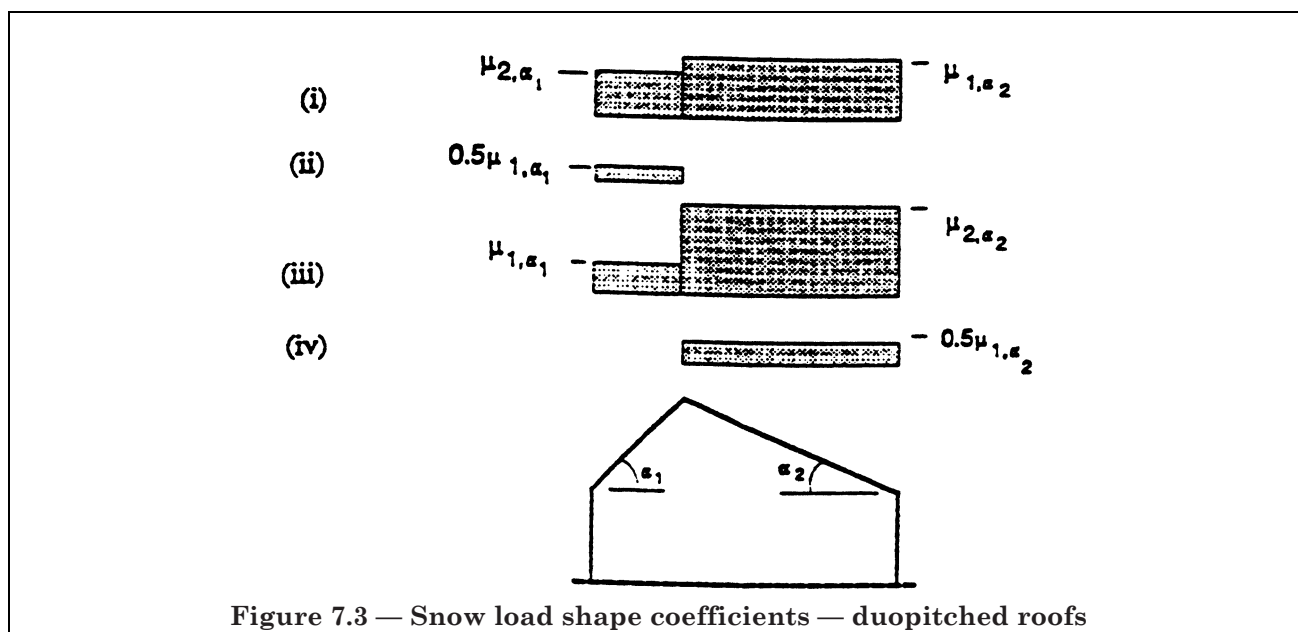


Figure 7.3 — Snow load shape coefficients — duopitched roofs

Table 7.2 — Snow load shape coefficient — duopitch roofs

Angle of pitch of roof,	$0^\circ \leq \alpha \leq 15^\circ$	$15^\circ < \alpha \leq 30^\circ$	$30^\circ < \alpha < 60^\circ$	$\alpha \geq 60^\circ$
Shape coefficient μ_1	0,8	0,8	$0,8(60 - \alpha)/30$	0,0
Shape coefficient μ_2	0,8	$0,8 + 0,6(\alpha - 15)/30$	$1,1(60 - \alpha)/30$	0,0

6) The most unfavourable of the load arrangements shown in Figure 7.3 is to be considered.

Multipitch Roofs

7) For multipitch roofs consideration should be given to either the uniform or asymmetric snow loads derived from 7.2 5) or the drift loading shown in Figure 7.4, whichever produces the most adverse effect. The snow load shape coefficients are given in Table 7.3.

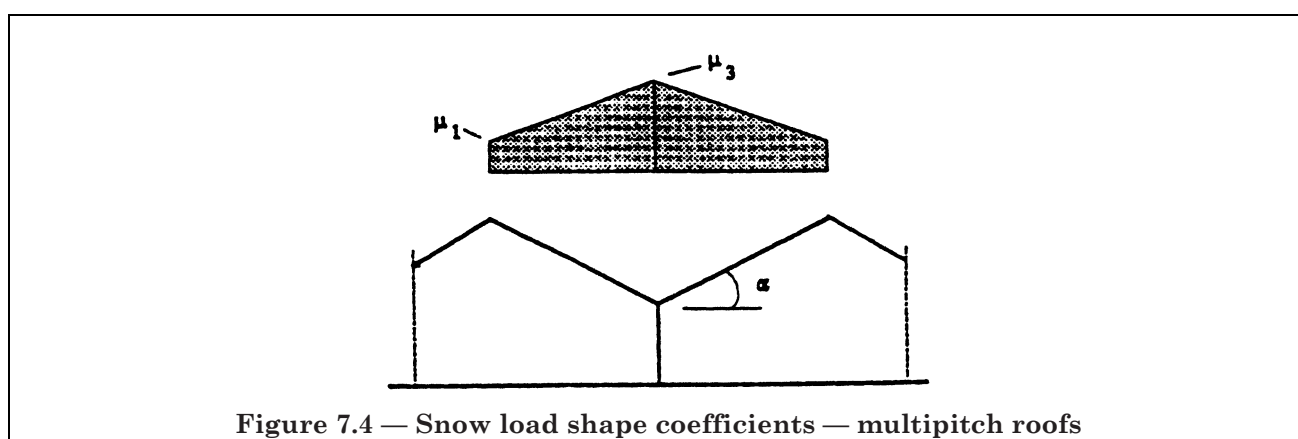


Figure 7.4 — Snow load shape coefficients — multipitch roofs

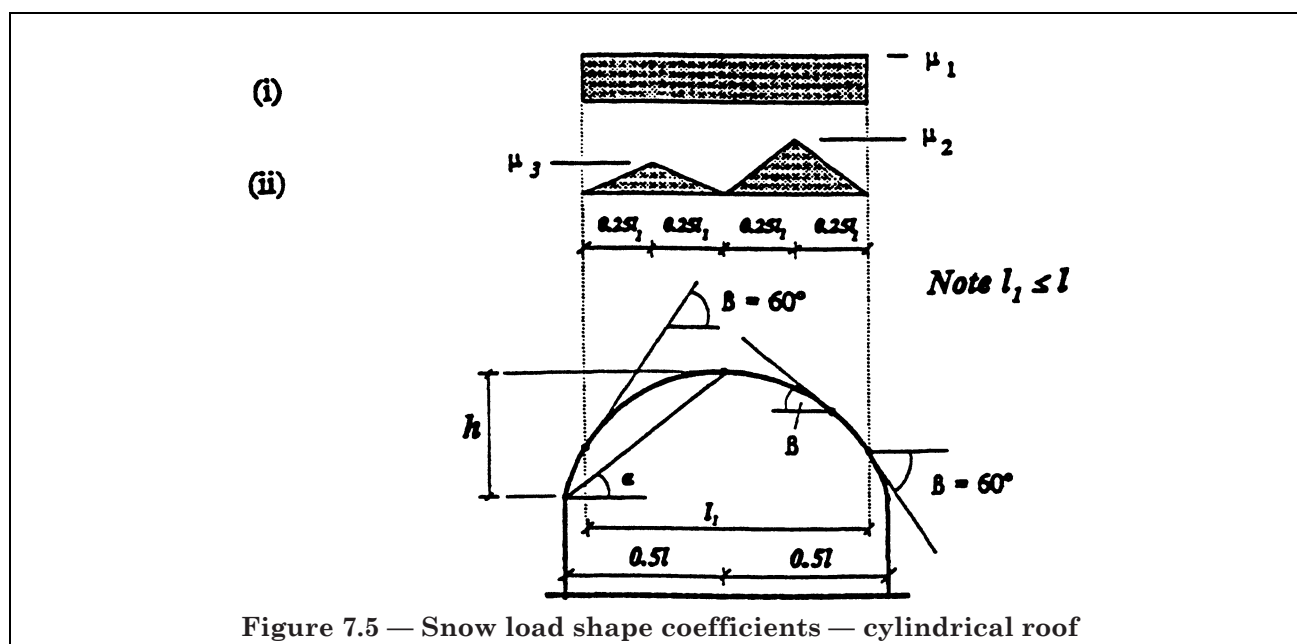
Table 7.3 — Snow load shape coefficients — multipitch roofs

Angle of pitch of roof	$0^\circ \leq \alpha \leq 30^\circ$	$30^\circ < \alpha < 60^\circ$
Shape coefficient μ_1	0,8	$0,8(60 - \alpha)/30$
Shape coefficient μ_3	$0,8 + 0,8\alpha/30$	1,6

8) Special consideration should be given to the snow load shape coefficients to be used for the design of multi-pitch roofs, where one or both sides of the valley have a slope greater than 60° .

7.3 Cylindrical roofs

1) For cylindrical roofs either the uniform or asymmetric snow loads shown in Figure 7.5, should be considered, whichever produces the most adverse effect. Cylindrical roofs include all cylindrical shells of any shape and single convex curvature. The values of the snow load shape coefficients are summarised in Figure 7.6. It is assumed that snow is not prevented from sliding off the roof.



2) The snow load shape coefficient are determined as follows:

$$\text{For } \beta \leq 60^\circ, \mu_1 = 0,8 \quad (7.1)$$

$$\mu_2 = 0,2 + 10h/l \quad \text{with the restriction } \mu_2 \leq [2,0] \quad (7.2)$$

$$\mu_3 = 0,5 \mu_2 \quad (7.3)$$

$$\text{For } \beta > 60^\circ, \mu_1 = \mu_2 = \mu_3 = 0 \quad (7.4)$$

