Eurocode 1: Action on structures

Part 1-3: General Actions
Snow Loads

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ECEC – European Council of Engineer‘s Chambers
CPD-Lectures at 15th of May, 2015, Belgrade/SRB

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Distinction between Principles and Application Rules

EN 1990, 1.4, constitutes

Principles comprise
- general statements and definitions without alternative;
- requirements and analytical models for which no alternative is permitted.

Application Rules are in accordance with the State of the Art and comply with the Principles

It is permissible to use ***alternative design rules*** different from the Application Rules, provided it is shown that the alternative rules accord with the relevant Principles and are equivalent with regard to the structural safety, serviceability and durability.

National Annex – NDP`s and NCI`s

The National Annex for EN 1991 1-3 is to only include:

NDP	– Characteristic values of snow loads on the ground, for example in the form of a map;
NDP	– National choice envisaged by notes in EN 1991 1-3 that allow choices;
	– Selection of procedure from amongst the parallel procedures defined, when this is allowed by a note in EN 1991 1-3;
NCI	– Reference to non-contradicting complementary information provided by National Regulation and requirements and / or additional publications which supplement this Eurocodes (e.g. roof shapes outside the scope of this part, and specialist aspects as described in 1.1(8));
NCI	– When needed nationally, prescriptive rules or simplifications for small buildings. In this case the scope of a small building will be in the National Annex.

Snow Loads on the Ground

s_k – characteristic snow load on the ground
The characteristic value at a location is determined from snow load records as the value having a return period of 50 yrs.

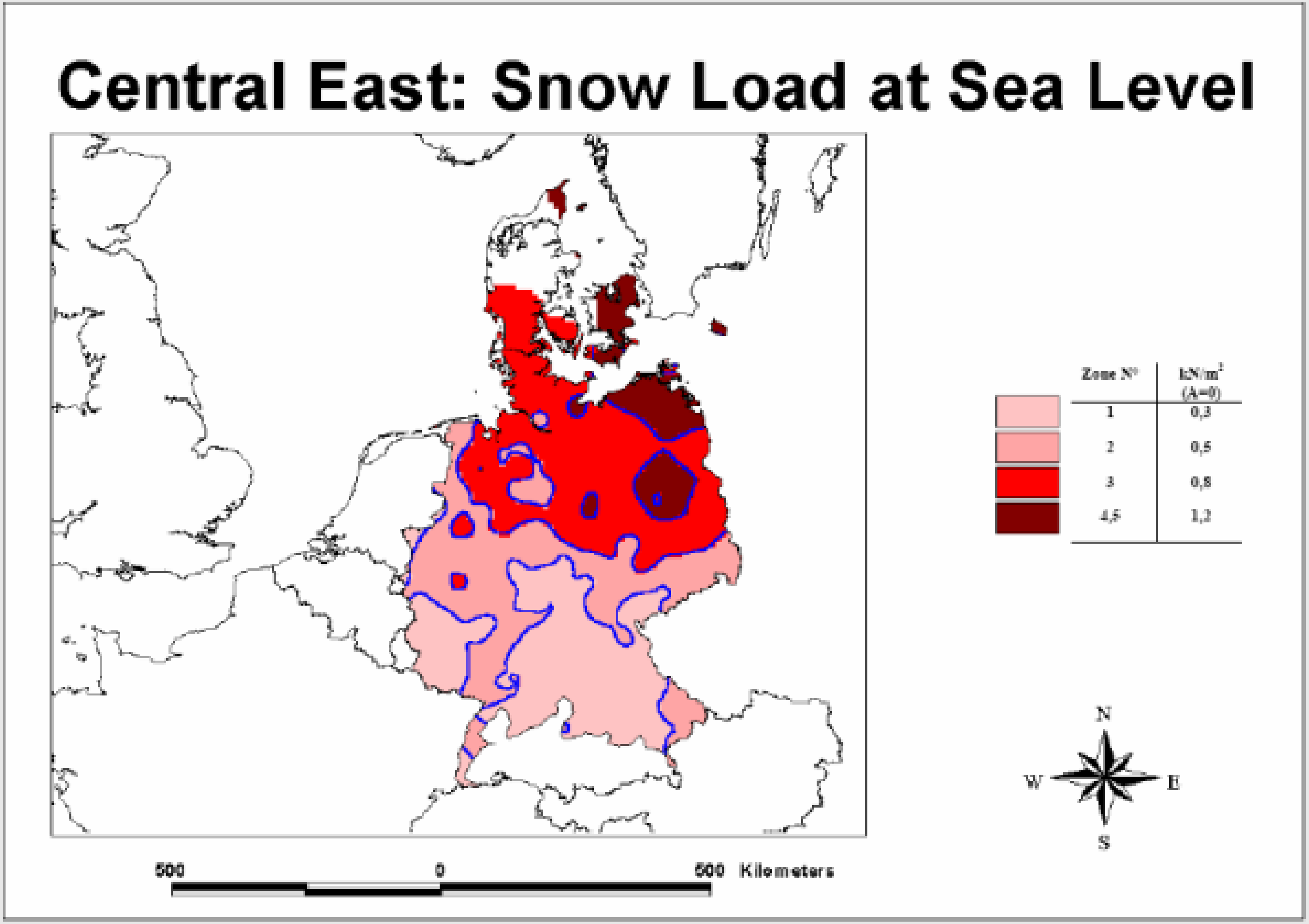
The National Annex specifies the values to be used, e.g. in form of a snow map.

$s_d = \gamma_s\, s_k$ – design snow load on the ground
The partial factor for the persistent/transient design situation is typically $\gamma_s = 1{,}5$

$s_{Ad} = C_{esl}\, s_k$ – accidental snow load on the ground

At particular locations, exceptionally high snow loads may occur which do not match with the statistical parameters obtained from the other data (outlier). Then
(1) The characteristic value is determined removing the outlier from the records;
(2) The outlier is taken into account by an accidental design situation with $s_{Ad} = C_{esl}\, s_k$
(3) The recommended value of is $C_{esl} = 2{,}0$

Annex C (informative): European Ground Snow Maps



Annex C (informative): European Ground Snow Maps

Altitude - Snow Load Relationships

Climatic Region	*Expression*
Alpine Region	$s_k = (0{,}642Z + 0{,}009)\left[1 + \left(\frac{A}{728}\right)^2\right]$
Central East	$s_k = (0{,}264Z - 0{,}002)\left[1 + \left(\frac{A}{256}\right)^2\right]$
Greece	$s_k = (0{,}420Z - 0{,}030)\left[1 + \left(\frac{A}{917}\right)^2\right]$
Iberian Peninsula	$s_k = (0{,}190Z - 0{,}095)\left[1 + \left(\frac{A}{524}\right)^2\right]$
Mediterranean Region	$s_k = (0{,}498Z - 0{,}209)\left[1 + \left(\frac{A}{452}\right)^2\right]$

s_k = Characteristic snow Load on the ground [kN/m^2]
A = Site altitude above Sea Level [m]
Z = Zone number given on the map.

Snow Loads on Roofs

Permanent and transient design situation

$$s = \mu_i \; C_e \; C_t \; s_k$$

μ_i snow load shape coefficient

s_k characteristic value of snow load on the ground

C_e exposure coefficient
accounting for wind exposure of the building site; C_e = 1 in general

C_t thermal coefficient
accounting for snow melting on roofs with high thermal transmittance; C_t = 1 in general

Accidental design situation caused by exceptional loads due to outliers in the recorded snow load data

$$s = \mu_i \; C_e \; C_t \; s_{Ad}$$

Ground Snow Load Map of Germany

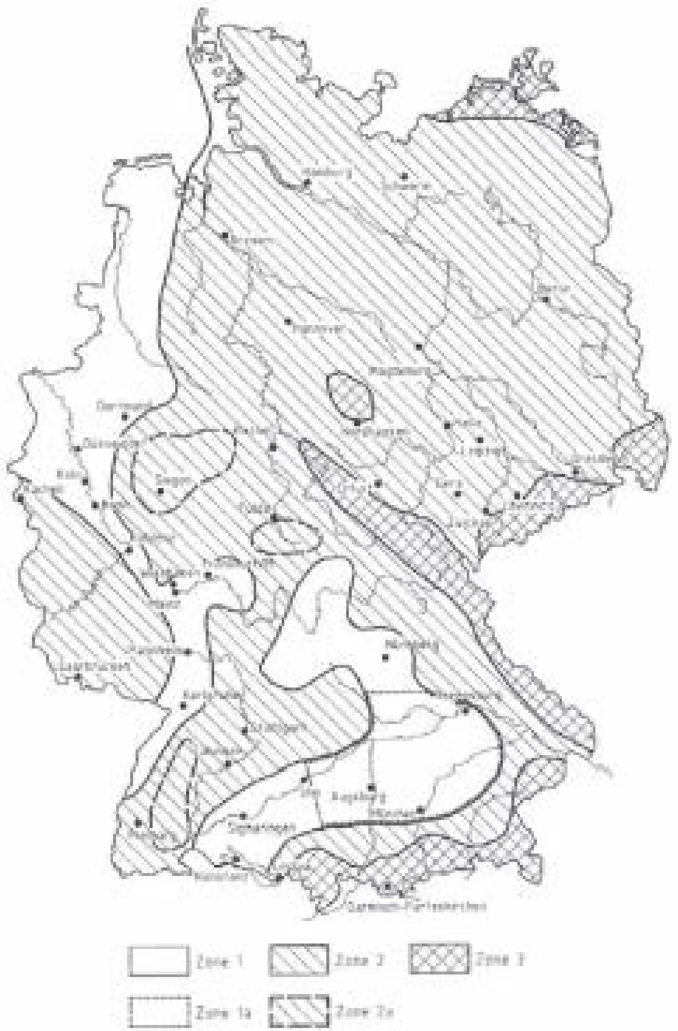
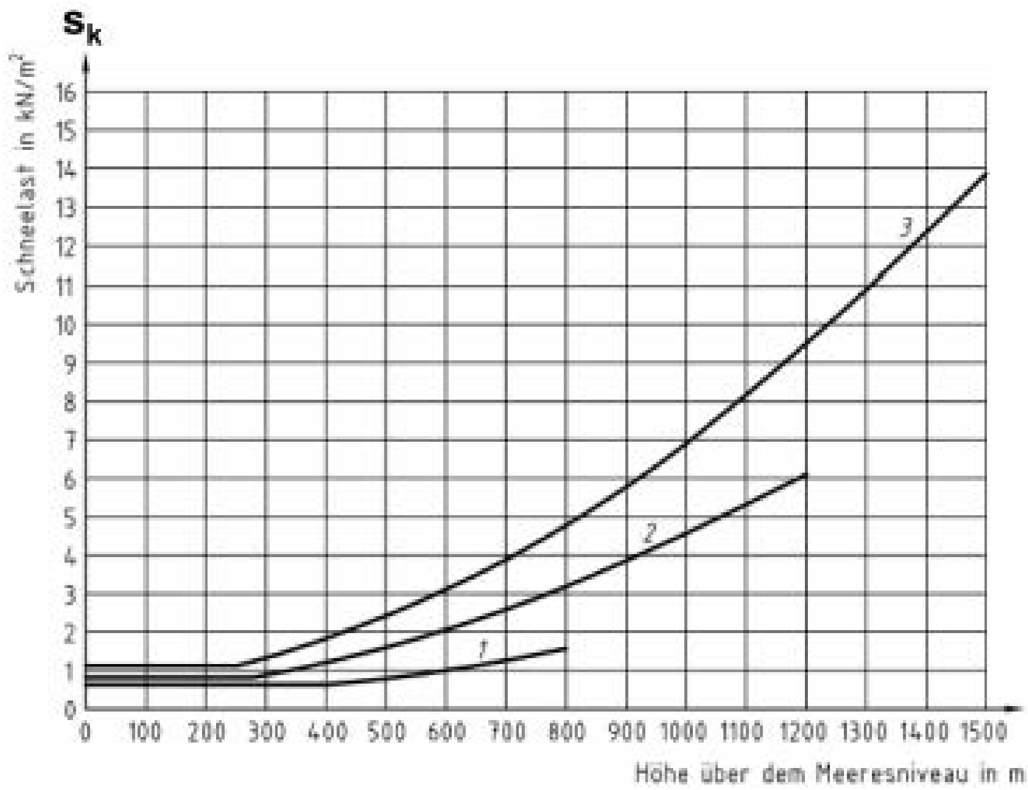
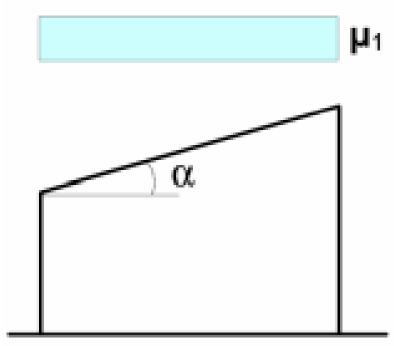


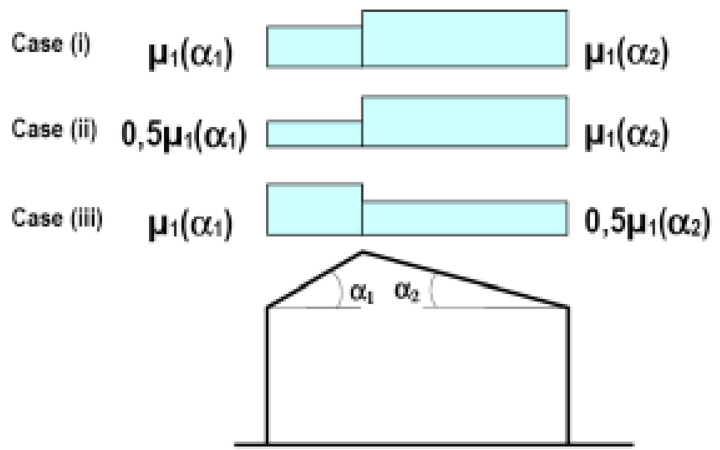
Bild 1 — Schneelastzonenkarte



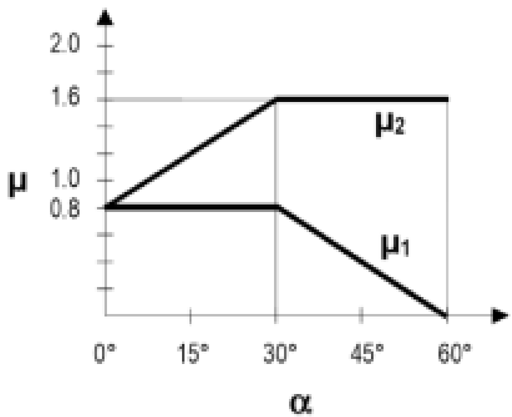
Snow Loads on Roofs: Roof Shape Coefficients μ

Load cases to be considered for single span roofs without snow fences

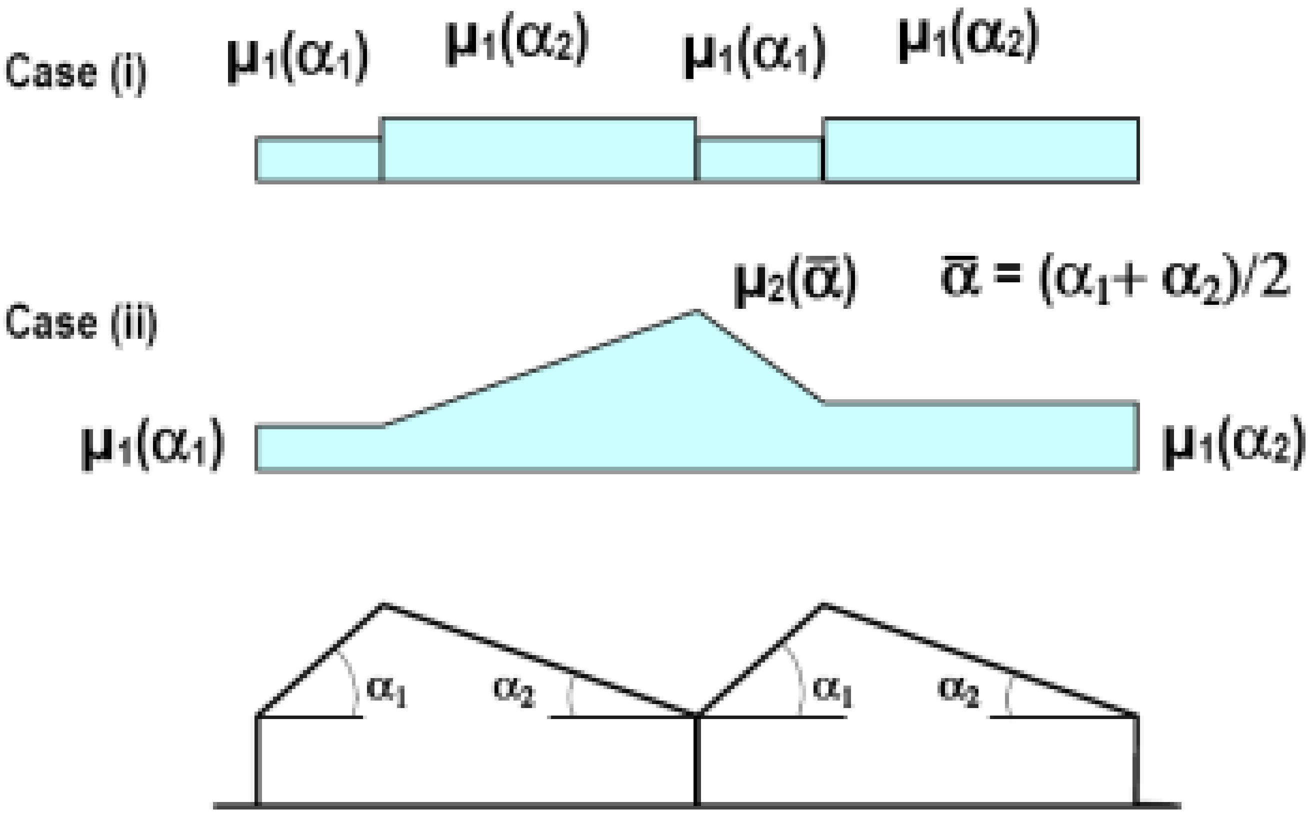




Roof shape coefficients μ

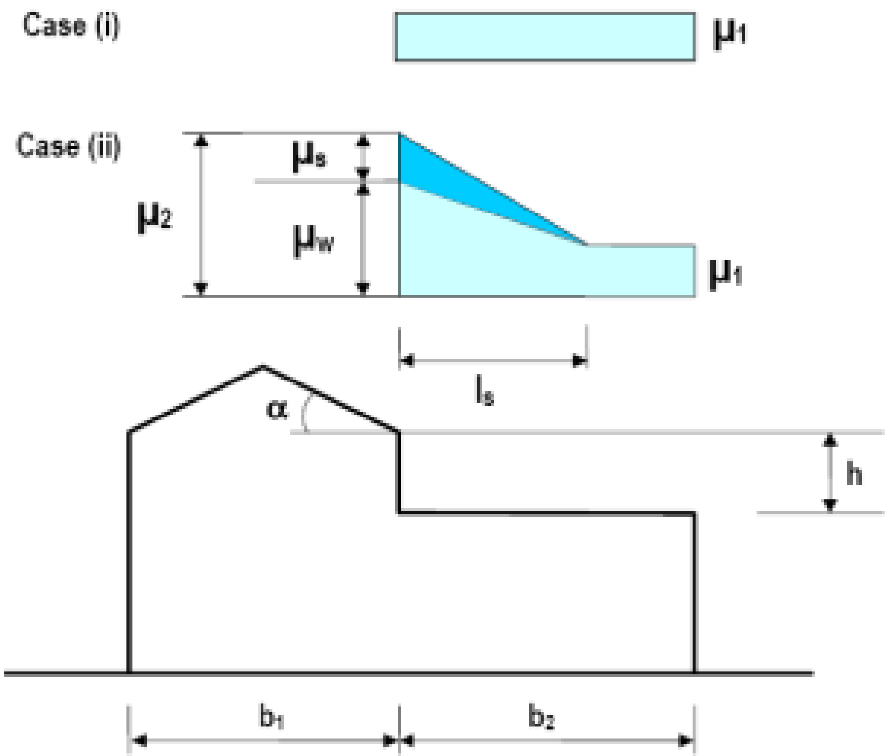


Snow Loads on Roofs: Multispan Roofs



The load case (ii) accounts for snow drifting

Snow Loads on Roofs abutting to taller Structures



(i) undrifted load arrangement

(ii) μ_s - sliding snow from the upper roof;
μ_w – snow drifted by wind

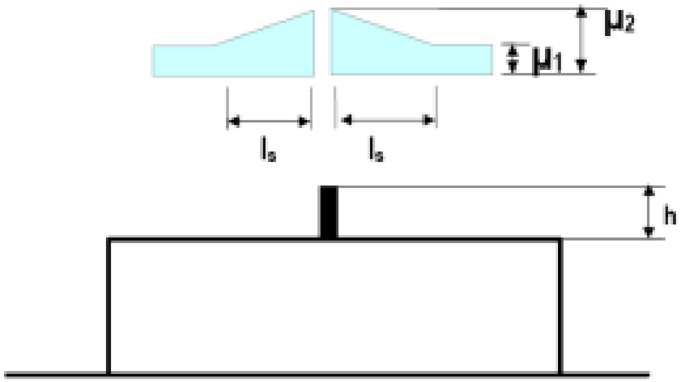
For $\alpha \leq 15°$ $\mu_s = 0$
For $\alpha \leq 15°$ μ_s is determined from an additional load amounting to 50% of the load on the adjacent slope on the upper roof (μ_1).

$\mu_w \cdot s_k = (b_1+b_2)/2 \cdot h \leq \gamma_s \cdot h$

with γ_s = 2 kN/m² - weight density of snow for this calculation

The snow load on the abutting roof may be rather high particularly for projecting roofs. The recommended range for μ_w is between 0,8 and 4.

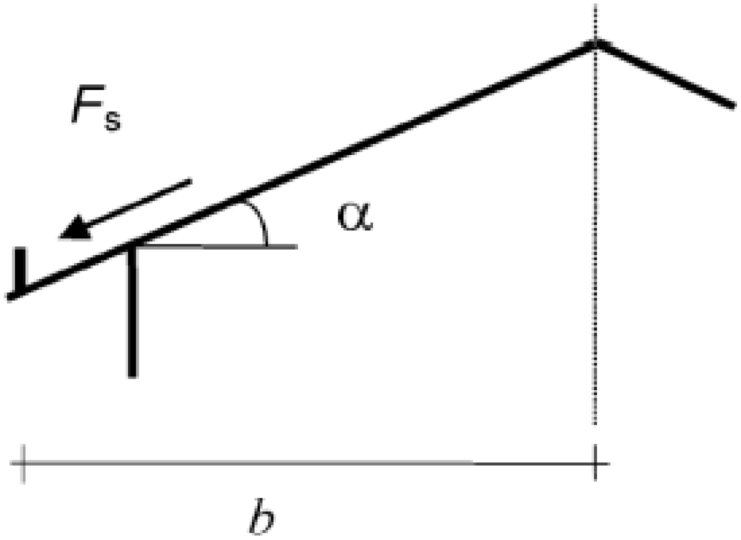
Snow Loads on Roofs: Local effects



(1) At projections and obstructions

(2) Snow overhanging the edge of a roof

Snow Loads on Roofs: Local effects



$$F_s = \mu_i \cdot s_k \cdot b \cdot \sin \alpha$$

(3) Snow on snow guards or fences due to snow sliding down a pitched or curved roofAt projections and obstructions

Exceptional Snow Drifts
Annex B gives additional snow load arrangements for cases of exceptional snow drift. This load case is treated as an accidental design situation.

Ice Pavilion Bad Reichenhall: Roof Failure under Snow Load
2. January 2006

Ice Pavilion Bad Reichenhall: Roof Failure under Snow Load
2. January 2006

Timber Box Girders of the roof

15 Fatalities
34 Injuries

Ice Pavilion Bad Reichenhall: Roof Failure under Snow Load
2. January 2006

Possible Causes of the failure

The roof structure was designed in 1975 as timber box girders.
The design was to carry a characteristic snow load of $s = 1{,}2\ kN/m^2$ in accordance with DIN 1055-5 (1975)

In 2006, a new DIN 1055-5 code became effective requiring a snow load of $s = 1{,}75\ kN/m^2$ for new structures and buildings.

The real snow load at the time of the failure was estimated from preceding precipitation, resulting in $s = 0{,}9\ kN/m^2$

Clearly, the failure was not caused by too small a design snow load.
The timber box girders of the roof failed due to

applying inappropriate wood glue in the fabrication;
insufficient maintenance.