Zeitschrift: IABSE reports = Rapports AIPC = IVBH Berichte

Band: 74 (1996)

Artikel: A comparison of the new ISO 4355 with CEN ENV 1991-2-3

Autor: Apeland, Kristoffer / Sandvik, Rune

DOI: https://doi.org/10.5169/seals-56060

A comparison of the new ISO 4355 with CEN ENV 1991-2-3

Kristoffer **APELAND**
Professor, dr.techn.
Oslo School of Architecture
Oslo, Norway

Rune **SANDVIK**
Cand. real.,
Norwegian Council for Building Standardization
Oslo, Norway

1. Introduction

Since the first ISO 4355 "Snow Loads on roofs" was published in 1981, it has to a great extent been the most used document in the process of developing National Snow Load Specifications.

ISO TC 98 "Basis for design of structures" decided in 1986 to start revisional work on the old ISO 4355. The revisional work has resulted in a revised ISO 4355 "Snow Loads on roofs" that was adopted in 1995, and is under publication. The background for ISO 4355 is discussed in Reference (1).

In 1991 CEN formed a specific Project Team (PT) in order to produce EC 1: Snow loads. The PT-work resulted in the ENV 1991-2-3: 1995 "Actions on structures - Snow loads". The background for the ENV is discussed in Reference (2).

The paper will make a comparison between the revised ISO 4355 and the ENV 1995 on snow loads on roofs.

Various parameters that are included in the code format for snow loads on roofs, e.g.:

- Exposure effects
- Thermal transmittance effects
- Shape coefficients
- Snow drift effects

will be discussed and the resulting loads will be compared.

The question, whether a load standard should be concerned only with the load specification as such, or should also incorporate reliability and safety considerations, will be briefly discussed.

2. Formats for the determination of snow load on roofs

2.1 ISO 4355 format

ISO 4355 presents an approximation for the snow load on roofs as a sum of a balanced load part, a drift load part and a slide load part. Thus

$$s = s_b + s_d + s_s \qquad (2.1)$$

in which the load parts are approximated by the introduction of product functions, i.e.

$$s_b = s_o C_e C_t \mu_b \qquad (2.2)$$

$$s_d = s_o C_e C_t \mu_b \mu_d \qquad (2.3)$$

$$s_s = s_o C_e C_t \mu_s \qquad (2.4)$$

in which

s_o is the characteristic snow load on the ground
C_e is an exposure coefficient treated in Annex B of rev. ISO 4355 and in 3.1
C_t is a thermal coefficient treated in Annex D of rev. ISO 4355 and in 3.2
μ_b is a slope reduction coefficient
μ_d is a drift load coefficient
μ_s is a slide load coefficient

In ISO 4355 it was decided to describe variation of the parameters with the roof angle β as continuous smooth functions, for which trigonometric functions can be suitable. Moreover, it is attempted to show the consequences of variation in parameter values. Thus, the slope reduction coefficient is defined as

$$\mu_b = \sqrt{\cos(C_m 1{,}5\beta)}\,; \quad \text{for } (C_m 1{,}5\beta) < 90°$$
$$\mu_b = 0\,; \quad \text{for } (C_m 1{,}5\beta) \geq 90° \qquad (2.5)$$

C_m is a surface material coefficient, which defines a reduction of the snow load on roofs for surface materials with low surface roughness, defined to vary between unity and 1,333, taking the 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

The variation of μ_b is shown in Fig. 1.

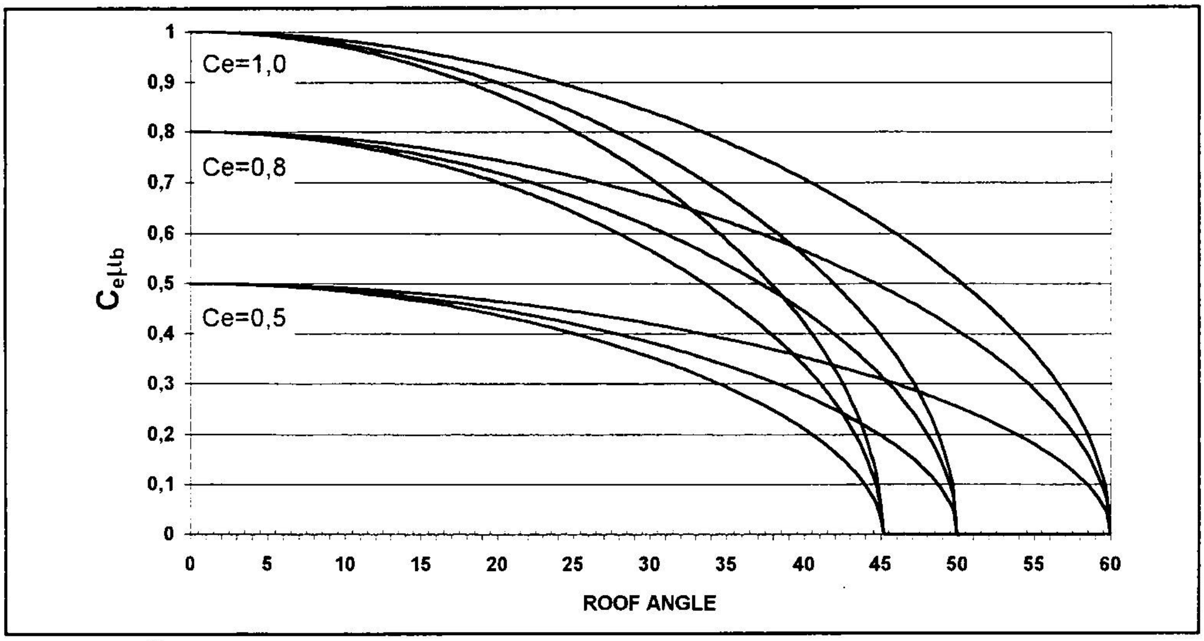

Figure 1 $C_e\mu_b$ for defined values of C_m

The drift load coefficient $\mu_b\mu_d$ is defined by the function

$$\mu_b\mu_d = \mu_b(2{,}2C_e\text{-}2{,}1C_e^2)\sin(3\beta)\ ;\ \text{for } 0°\leq\beta\leq 60°$$
$$\mu_b\mu_d = 0\ ;\ \text{for } \beta>60°$$

The form of the drift load coefficient ensures that a certain drift load part always is considered even for regions with very calm winter conditons; i.e. C_e = 1,0.

The slide load shape coefficient μ_s, giving a slide load from an upper part of a roof onto a lower roof of a multilevel roof, is defined as an approximate load model in connection with shape coefficients for multilevel roofs, in clause 5.4.5.6 of the ISO 4355.

2.2 CEN ENV 1991-2-3 format

CEN ENV 1991-2-3 proposes the following format for the snow load on roofs:

$$s = \mu_i C_e C_t s_k \qquad (2.7)$$

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

3. Comparison of ISO 4355 and CEN ENV 1991-2-3

3.1 Exposure coefficient C_e

In ISO 4355 the exposure coefficient C_e is defined as a reduction coefficient having its maximum value $C_e = 1{,}0$ for calm winter conditions.
For "normal" winter conditions it is recommended to set $C_e = 0{,}8$.
The exposure coefficients may be determined from Annex B, mainly depending on defined winter wind conditions and winter temperature conditions, as shown in Table 1.

		Winter wind category		
		I	II	III
Winter temperature category	A	1,0	1,0	0,8
	B	1,0	0,8	0,6
	C	0,8	0,8	0,5

Table 1 Exposure coefficient, C_e

CEN ENV 1991-2-3 has introduced an exposure coefficient C_e into the format. However, since the ENV applies the shape coefficients of the old ISO 4355, which did not have an exposure coefficient in the format, and thus had normal exposure with a value of 0,8 in the shape coefficients, the ENV had to define the normal exposure as $C_e = 1{,}0$.
It is unfortunate that the coefficient has the same symbol as in ISO 4355, however, with a different scaling.
In ENV 1991-2-3 no specifications are given for possible variation of C_e. The author's suggestion is to harmonize the use of C_e before the final EN is produced. If this is not done, misunderstandings may result.
The national codes of Canada and the United States have exposure coefficients in their formats. Since symbols are different, no misunderstandings are expected.
The ENV opens for national authorities to specify values of C_e.

3.2 Thermal transmittance effects

With the increasing use of glass roofs over the last decade the Working Group of ISO TC 98, SC3, felt that thermal transmittance effects should be introduced into the format, and developed a model for such reductions. This model is presented in Annex D of ISO 4355. However, it is only informative. It could be mentioned that the same approach to C_t is an integral part of the Norwegian standard NS3479 since 1990, and lately also incorporated in Swedish specifications on snow loads. Norwegian experience with the use of C_t ranging from approx. 0,35 - 1,0 is good.

It is felt that CEN should add such guidelines in the EN version.

3.3 Comparison of shape coefficients and snow drift effects for pitched roofs

A comparison of the variation of snow load on a pitched roof as a function of the roof angle β, is shown for the windward side on Fig. 2 and for the leeside on Fig. 3.

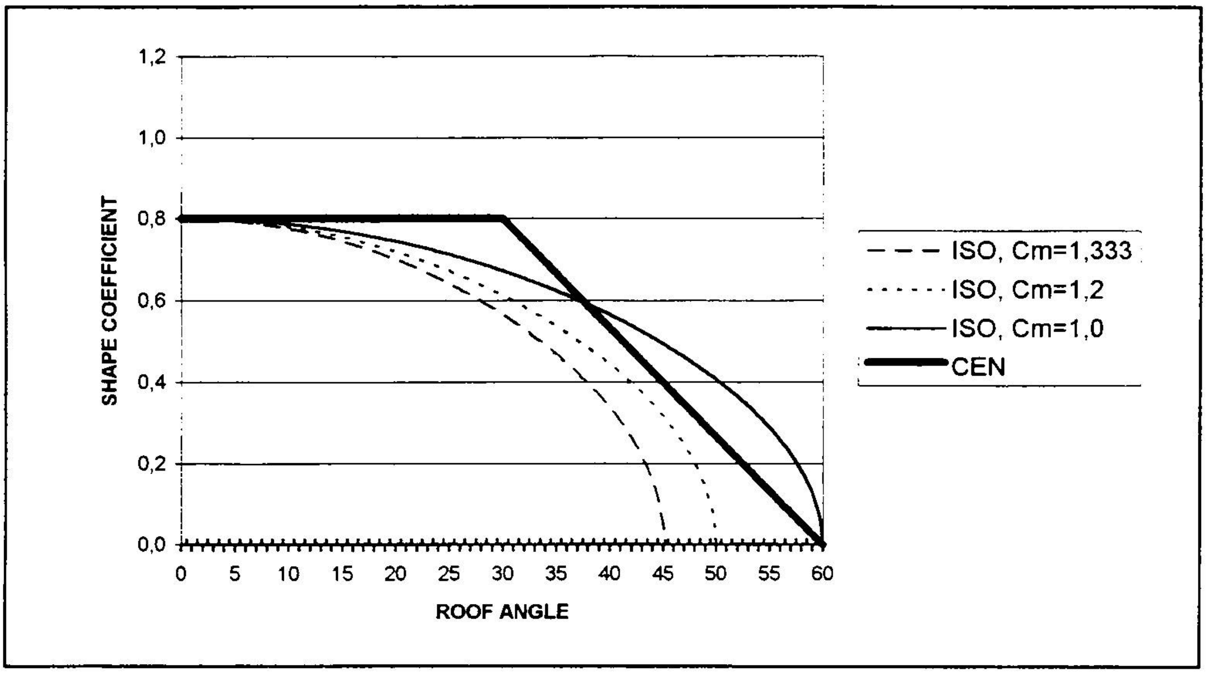

Figure 2

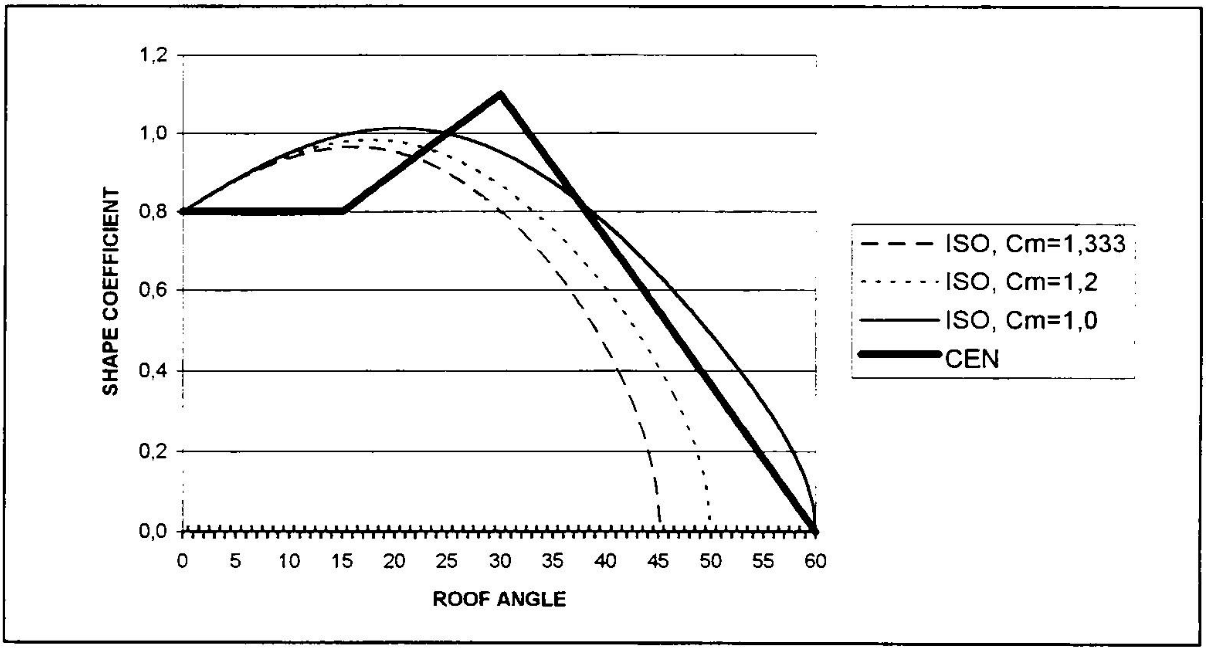

Figure 3

Taking account of new measurements of snow load on roofs, the ISO 4355 has reduced the maximum leeside load by almost 20 percent as compared with the old ISO 4355. Moreover, the maximum drift load as a function of the roof angle has been changed from $\beta = 30°$ to approximately $\beta = 20°$ in accordance with measurements and experience.
The ENV, on the other hand, has reduced the maximum leeside load by approximately 10 percent. However, the maximum is still for $\beta = 30°$.

These differences should be studied, and possibly eliminated, before the final EN is produced.

For monopitch roofs the new ISO 4355 has added a drift load part to the balanced load, leading to an increased load for monopitch roofs. The ENV 1991-2-3 has introduced an extra load case for monopitched roofs. It is hard to see that this load case will cause more unfavorable conditions than the ordinary load.

3.4 Comparison of shape coefficients for curved roofs

The old ISO 4355, 1981, gave two different load cases, which were based on Russian measurements and specifications. Clause 3.2 of the old ISO 4355 had a prescription about partial loading, which said that the load should be applied according to the shape coefficient distribution on any given portion of the roof area, and zero load on the remainder of the area. This led to particularly unfavorable conditions for arhces, which are very sensitive to asymmetrical loading.

In the new ISO 4355, 1995, it is recommended that only half of the snow load on arches shall be considered to be a variable free action, which leads to more favorable conditions for arches. The CEN ENV 1991-2-3 presents two different load cases. The load case II seems to yield larger bending moments than does the case 2 of the old ISO 4355. Since the ENV defines the snow load as a variable free action, the ENV may lead to much more severe conditions for arches than does the new ISO 4355. This problem should be studied thoroughly before the EN-document is finalized.

3.5 Comparison of shape coefficients for multilevel roofs

The ENV 1991-2-3 has prescribed the same shape coefficients as those used in the old ISO 4355, 1981.

The new ISO 4355, 1995, gives more prescriptions for multilevel roofs, which are based on new American research and load surveys, the results of which are felt to be more realistic under varying conditions than were the results of the old ISO 4355, 1981.

In Fig. 4 the load on the lower roof (apart from possible slide load), represented with the shape coefficient μ_w of the CEN ENV, is compared with the sum of balanced load and drift load according to the new ISO 4355.

It should be noted that, in accordance with American surveys, the shape coefficient diminshes with increasing ground load s_0, whereas the shape coefficient of the CEN ENV and the old ISO 4355 is independent of s_0.

It also should be noted that the new ISO 4355 yields larger loads on lower roofs having small differences in level between upper and lower roof, than does the ENV and the old ISO 4355. The cause for this increase is observations of snow load accumulation on the ground or on lower level roofs for arches or pitched roofs sloping down to the lower level, see clause 5.4.5.7 of the new ISO 4355.

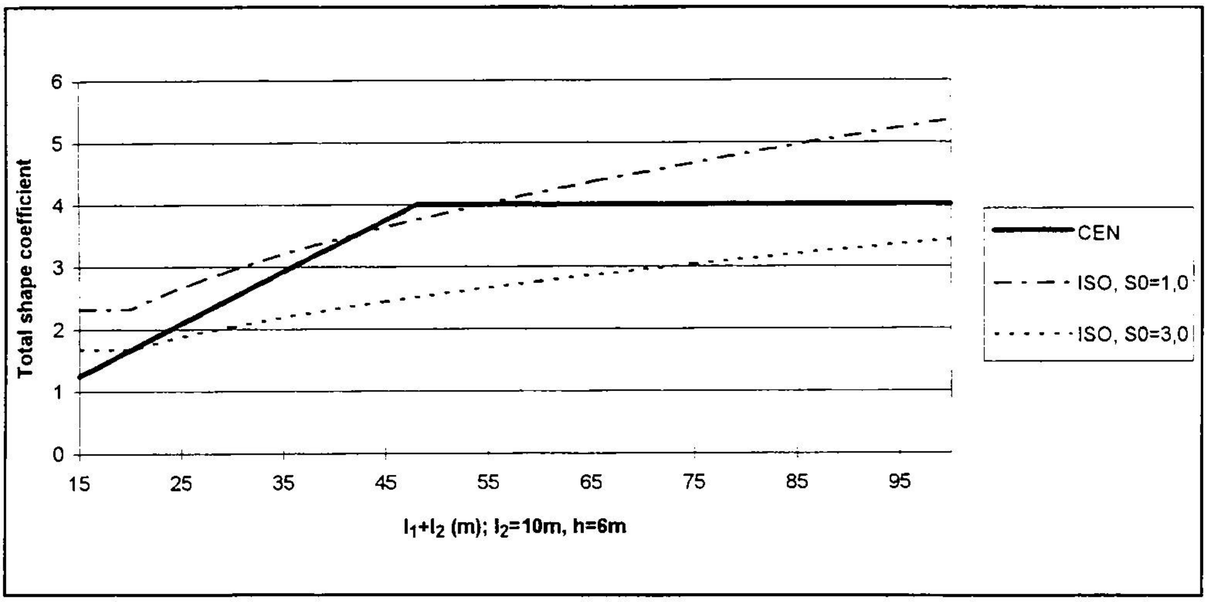

Figure 4

4. Action codes and reliability codes

When the design code is subdivided into governing reliability codes and action codes, it is the author's opinion that the action codes should be restricted to the prescription of the loads only, whereas the reliability codes should specify design situations and safety considerations.
The new ISO 4355, 1995, is as far as possible based on this principle.

However, the ENV 1991-2-3, classifies the snow load to be an accidental action under specified conditions. The author feels that this may lead to misunderstandings when applying the assembly of documents.

Firstly, classification of snow load as an accidental action was never suggested in ISO, and is not in accordance with the definition of the term. The consequences should be investigated carefully before a transformation to EN.

Secondly, if it is considered appropriate to treat snow load as an accidental action, this should be treated in the ENV 1991-1, Basis of design, rather than in ENV 1991-2-3.

5. Concluding remark

Several (important) differences, some of them with significant effects on the design snow load, are stated. It is felt that CEN ENV 1991-2-3: Actions on Structures - Snow loads should be examined as far as consequences are concerned, before the final EN-document is decided upon. In this connection some of the results of the new ISO 4355 should be studied in order to arrive at more harmonized documents in CEN and ISO..

6. References

1. Apeland, K.: "Standardization of Snow Loads on Roofs DIS 4355: Revision of ISO Standard 4355", Second International Conference on Snow Engineering, 1992. CRREL Special Report 92-27.

2. Del Corso, R., Gränzer, M., Gulvanessian, H., Raoul, J., Sandvik, R., Sanpaolesi, L., Stiefel, U.: "New European Code for Snow Loads, Background Document", Proc. Dept. Struct. Eng., University of Pisa, 1995.