DANISH ENERGY AGENCY

DS/EN 1991-1-4 DK NA:2015

National Annex to

Eurocode 1: Actions on structures -
Part 1-4: General actions - Wind actions

Foreword

This national annex (NA) is a revision of DS/EN 1991-1-4 DK NA:2010-03 and addendum 1 of 2010-03-30, and replaces both documents on 2015-07-15. For a transition period until 2015-11-01, this National Annex as well as the previous National Annex will be applicable. Technical changes have been made in clauses 7.2.3(4) and 7.2.10(3), note 2.

Previous versions of and addenda to this NA as well as an overview of all NAs can be found at www.eurocodes.dk

This NA lays down the conditions for the implementation in Denmark of DS/EN 1991-1-4 for construction works in conformity with the Danish Building Act or the building legislation. Other parties can put this NA into effect by referring thereto.

A National Annex contains national provisions, viz. nationally applicable values or selected methods. The Annex may furthermore give complementary, non-contradictory information.

This NA includes:

- an overview of possible national choices and clauses containing complementary information;
- national choices;
- complementary, non-contradictory information.

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Overview of possible national choices and complementary information

The list below identifies the clauses where national choices are possible and the applicable/not applicable informative annexes. Furthermore, clauses giving complementary information are identified. Complementary information is given at the end of this National Annex.

Clause	Subject	National choice[1)]	Complementary information
1.5(2)	Design assisted by testing and measurements	Unchanged	
4.1(1)	National climatic information	No choice made	
4.2(1)P Note 2	Fundamental value of the basic wind velocity	National choice	
4.2(2)P Notes 1, 2, 3 and 5	Directional factor, seasonal factor and modified basic wind velocity	National choice	
4.3.1(1) Notes 1 and 2	Orography factor and mean wind velocity	Unchanged	
4.3.2(1)	Roughness factor	National choice	
4.3.2(2)	Determination of terrain roughness	Unchanged	
4.3.3(1)	Determination of orography factor	Unchanged	
4.3.4(1)	Effect of neighbouring structures	Unchanged	
4.3.5(1)	Effect of closely spaced buildings	Unchanged	
4.4(1) Note 2	Turbulence intensity	Unchanged	
4.5(1) Notes 1 and 2	Characteristic peak velocity pressure and air density	Unchanged	
5.3(5)	Lack of correlation	National choice	
6.1(1)	Structural factor	Unchanged	
6.3.1(1) Note 3	Procedure for determining the dynamic response	National choice	
6.3.2(1)	Determination of displacements and accelerations	National choice	
7.1.2(2)	Asymmetry and torsional effects	Unchanged	
7.1.3(1)	Effects of ice and snow	Unchanged	
7.2.1(1) Note 2	Force coefficients for loaded areas between 1 m² and 10 m²	Unchanged	
7.2.2(1)	Reference heights	Unchanged	
7.2.2(2) Note 1	Pressure coefficients - walls	Unchanged	
7.2.3(2)	Pressure coefficients – flat roofs	Unchanged	
7.2.3(4)	Pressure coefficients – flat roofs	National choice	
7.2.4(1)	Pressure coefficients – monopitch roofs	Unchanged	
7.2.4(3)	Pressure coefficients – monopitch roofs	Unchanged	
7.2.5(1)	Pressure coefficients – duopitch roofs	Unchanged	

Clause	**Subject**	**National choice[1)]**	**Complementary information**
7.2.5(3)	Pressure coefficients – duopitch roofs	Unchanged	
7.2.6(1)	Pressure coefficients – hipped roofs	Unchanged	
7.2.6(3)	Pressure coefficients – hipped roofs	Unchanged	
7.2.7	Pressure coefficients – multispan roofs	Unchanged	
7.2.8(1)	Pressure coefficients – vaulted roofs and domes	Unchanged	
7.2.9(2)	Internal pressure – opening ratio	Unchanged	
7.2.9(6) Note 2	Internal pressure – without a dominant face		Complementary information
7.2.10(3) Note 1	Wind pressure on walls or roofs with more than one skin	Unchanged	
7.2.10(3) Note 2	Wind pressure on walls or roofs with more than one skin	National choice	
7.3(6)	Canopy roofs – monopitch roofs	Unchanged	
7.4.1(1)	Free-standing walls and parapets	Unchanged	
7.4.3(2)	Horizontal eccentricity for signboards	Unchanged	
7.6(1) Note 1	Effects of rounded corners	Unchanged	
7.7(1) Note 1	Force coefficients for prisms with sharp edged sections	Unchanged	
7.8(1)	Force coefficients for prisms with regular polygonal section (m>4)	Unchanged	
7.9.2(2)	Force coefficient – surface roughness, *k*, for worn surfaces	Unchanged	
7.9.3 Table 7.14	Force coefficients for vertical cylinders in a row arrangement	National choice	
7.10(1) Note 1	Force coefficients for spheres	Unchanged	
7.11(1) Note 2	Reduction factors for scaffolding	Unchanged	
7.13(1)	Reduction factors for free-end flow for cylinders or prisms	Unchanged	
7.13(2)	Slenderness and reduction factors	Unchanged	
8.1(1) Notes 1 and 2	Wind actions on bridges	Not relevant for building structures	
8.1(4)	Substitute value for the fundamental value of the basic wind velocity	Not relevant for building structures	
8.1(5)	Substitute value for the fundamental value of the basic wind velocity	Not relevant for building structures	

Clause	Subject	National choice[1)]	Complementary information
8.2(1) Note 1	Dynamic response procedure for bridges	Not relevant for building structures	
8.3(1)	Force coefficients for wind force on parapets etc. on bridges	Not relevant for building structures	
8.3.1(2)	Reduction factor for wind actions on bridges	Not relevant for building structures	
8.3.2(1)	Force coefficient for wind actions on bridges	Not relevant for building structures	
8.3.3(1) Note 1	Force coefficient for wind actions on bridges	Not relevant for building structures	
8.3.4(1)	Force coefficient for wind actions on bridges	Not relevant for building structures	
8.4.2(1) Notes 1 and 2	Wind effects on piers	Not relevant for building structures	
A.2(1)	Inhomogeneous terrain	National choice	
E.1.3.3(1)	Air density	Unchanged	
E.1.5.1(1) Notes 1 and 2	Choice between procedures 1 and 2	National choice	
E.1.5.1(3)	Choice between procedures 1 and 2	National choice	
E.1.5.2.6(1) Note 1	Number of load cycles	National choice	
E.1.5.3(2) Note 1	Air density	Unchanged	
E.1.5.3(4)	Influence of turbulence intensity	National choice	
E.1.5.3(6)	Peak factor	Unchanged	
E.3(2)	Stability parameter	No choice made	

1)
Unchanged: The recommendation in the Eurocode is followed.
National choice: A national choice has been made.
Not relevant for building structures: See the National Annexes published by the Danish Road Directorate and Banedanmark.
No choice made: The Eurocode does not recommend values or methods, but allows the option of determining national values or methods.

National choices

4.2 (1)P NOTE 2 Fundamental value of the basic wind velocity

The fundamental value of the basic wind velocity, $v_{b,0}$, is taken as 24 m/s everywhere in Denmark apart from a border zone in Jutland with localities less than 25 km from the North Sea and Ringkøbing Fjord. The fundamental value of the basic wind velocity in the border zone is taken as 27 m/s at the coastline decreasing linearly to 24 m/s at the other edge of the border zone. For the determination of the border zone, local orographic conditions, e.g. the inlets of Western Jutland, shall be taken into account.

4.2 (2)P NOTES 1, 2, 3 and 5 Directional factor and seasonal factor and modified basic wind velocity

The modified basic wind velocity is not changed.

The directional factor squared, c_{dir}^2, is given in table 1a, where the wind direction denotes the midpoint of the 30° sector from where the wind comes. The directional factor should be applied together with the terrain evaluation to determine the characteristic wind velocity from the wind direction considered, if the direction conditions can be assumed to exist as long as the structure.

Table 1a DK NA - Directional factor squared c_{dir}^2

	N	NNE	ENE	E	ESE	SSE
Wind direction	0°	30°	60°	90°	120°	150°
c_{dir}^2	0,8	0,8	0,8	0,8	0,8	0,8
	S	SSW	WSW	W	WNW	NNW
Wind direction	180°	210°	240°	270°	300°	330°
c_{dir}^2	0,8	0,8	0,9	1,0	1,0	0,9

The seasonal factor squared is given in Table 1b DK NA.

Table 1b DK NA - Seasonal factor squared c_{season}^2

Months.	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
c_{season}^2	1,0	1,0	0,9	0,9	0,8	0,7	0,7	0,7	0,8	0,9	0,9	1,0

4.3.2 (1) Terrain roughness

The recommended procedure for determining the roughness factor at height z is given by Expression (4.4).

The following is added at the end of the NOTE after " … sufficiently, see (2) "Costal areas exposed to onshore wind are assigned to terrain category I for the wind directions in question"

In Table 4.1, terrain category I is extended to include "and costal area exposed to the open sea."

5.3 (5) Lack of correlation
The effect of the lack of correlation of wind pressures between the windward and leeward sides may be taken into account when determining the wind force.

6.3.1(1) Note 3 Procedure for determining the dynamic response
The procedure given in Annex C is applied.

6.3.2(1) Determination of displacements and accelerations
The procedure given in Annex C is applied.

7.2.3(4) Pressure coefficients – flat roofs
The pressure coefficient for zone I of -0,2 is changed to -0,5.

7.2.10 (3), Note 2, Wind pressure on walls with more than one skin
In the first indent ("-"), the following is added after the last sentence: For zones denoted "A" in Figure 7.5, the pressure coefficient stated for the permeable outer skin may underestimate the wind force. This wind force is not underestimated if the pressure coefficient is taken as -0,9.

7.9.3 Table 7.14, Force coefficients for vertical cylinders in a row arrangement
Table 7.14 may underestimate the wind force for a/b < 2,5

A.2 (1) Inhomogeneous terrain
Procedure 1 is applied. For procedure 1, ”category 0” is replaced by ”category I” and “categories I to III” is replaced by "categories II and III".

E.1.5.1 (1), Notes 1 and 2, Choice between procedures 1 and 2
Procedure 2 is applied.

En1.5.1 (3), Choice between procedures 1 and 2
Procedure 2 is applied.

E.1.5.2.6 (1), Note 1, Number of load cycles - fatigue actions
For structures where the characteristic maximum displacement determined in E.1.5.3 of EN 1991-1-4:2005 is less than approx.10% of the cross-wind dimensions, the fatigue actions may be determined by means of E.1.5.3 of EN 1991-1-4:2005 using the constants C_c and K_a as stated below.

The dependence of the constant C_c of the wind velocity ratio $v_m / v_{crit,i}$, where v_m is the 10 minute mean wind velocity and $v_{crit,i}$ is the resonance wind velocity, is determined approximately by:

$$C_c = C_c(Table\,E.6)\left(\frac{v_m}{v_{crit,i}}\right)^{3/2} \exp\left[-\frac{1}{2}\left(\frac{1 - v_{crit,i}/v_m}{B}\right)^2\right]$$

$C_c(Table\,E.6)$ is given in Table E.6 in EN 1991-1-4, and B can approximately be taken as $B = 0{,}1$. The 10 minute mean wind velocity v_m and the resonance wind velocity $v_{crit,i}$ are determined at the height above ground with the largest movement of the structure.

The movement of the structure is not underestimated if the dependence of the aerodynamic damping constant K_a of the wind velocity ratio $v_m / v_{crit,i}$ and the turbulence intensity I_v is determined by the following simplified and approximated expression:

$$K_a = K_{a,\max}\, h(I_v)\, g\left(\frac{v_m}{v_{crit,i}}\right)$$

The function $h(I_v)$ is defined in E.1.5.3 (4) below. The function g assumes its maximum value equal to 1 for $v_m = v_{crit,i}$ and is taken to decrease linearly from 1 to 0 for $v_m = 2v_{crit,i}$. g is taken as 0 for $v_m < v_{crit,i}$ and $v_m > 2v_{crit,i}$.

The frequency of mean wind velocities up to approx. 15-20 m/s can be determined on the basis of the European wind atlas, see Troen, I.; Petersen, B. & Lundtang, E., 1989, *European Wind atlas*, Risø, Roskilde.

For wind over a terrain of a roughness length between approx. 0,01 m and approx. 0,05 m, the frequencies of the different turbulence intensities can be evaluated on the basis of a normal distribution using the mean value given in 4.4 (1) in EN 1991-1-4 and a deviation decreasing gradually from approx. 0,06 at mean wind velocities smaller than approx. 5 m/s to approx. 0,03 for mean wind velocities of approx. 10 m/s. The probability mass of the normal distribution for negative arguments should be taken here to correspond to a turbulence intensity of 0.

For fatigue analyses based on the specifications stated above, the coefficient of variation of the fatigue loads should be taken as 30% when the partial factor is determined, see the National Annex to EN 1990.

E.1.5.3 (4) Influence of turbulence intensity

The effect of rhythmic vortex shedding depends on the turbulence intensity of the wind. For 10 minute wind velocities larger than approx.15 m/s, the turbulence intensity of the wind is determined using

4.4 (1) in EN 1991-1-4:2005. For 10 minute wind velocities smaller than approx. 10 m/s, consideration should be given to rhythmic vortex shedding in turbulence free wind which occurs under certain, relatively rare meteorological conditions.

The movement of the structure is not underestimated if the dependence of the aerodynamic damping constant K_a of the turbulence intensity I_v is determined by means of the following simplified and approximated expression:

$$K_a(I_v) = K_{a,\max} h(I_v)$$

where $K_{a,\max}$ is given in Table E.6 in EN 1991-1-4:2005. The function h is determined from $h(I_v) = 1 - 3I_v$ for $0 \leq I_v \leq 0{,}25$ og $h(I_v) = 0{,}25$ for $I_v > 0{,}25$. The turbulence intensity I_v is determined at the height above ground with the largest movement of the structure.

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Complementary, non-contradictory information

7.2.9(6) Note2, Internal pressure – without a dominant face

The following is added at the end of the note after " ... more onerous of +0,2 and -0,3": ”In this case partitions can be taken as a wind action corresponding to the pressure coefficient of 0,4 due to pressure variations in the rooms separated by the partitions.”

Literature

Troen, I.; Petersen, B. & Lundtang, E., 1989, *European Wind Atlas*, Risø, Roskilde.