DS/EN 1991-1-1 DK NA:2013

National Annex to

Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings

Foreword

This national annex (NA) is a revision of DS/EN 1991-1-1 DK NA:2011 and replaces this on 2013-10-25. In addition to editorial changes, technical modifications have been introduced regarding Annex B and the rhythmic crowd load in Annex C (previously, requirements for rhythmic crowd loads were given in the National Annex to DS/EN 1990).

Previous versions, addenda and an overview of all National Annexes can be found at www.eurocodes.dk

This NA lays down the conditions for the implementation in Denmark of DS/EN 1991-1-1 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.

This NA includes:

- an overview of possible national choices and complementary information;
- national choices;
- complementary (non-contradictory) information.

The numbering refers to the clauses where choices are allowed and/or complementary information is given. To the extent possible, the heading/subject is identical to the heading of the clause in the Eurocode, but as references are at a more detailed level than the headings, the heading/subject has in several cases been made more explicit.

Overview of possible national choices and clauses containing complementary information

The overview 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 document.

Clause	**Subject**	**Choice**	**Complementary information**
1.4.7	Movable partitions		Complementary information
2.1(2)	Classification of actions – Self-weight		Complementary information
2.2(3)	Imposed loads - Rhythmic crowd loads	National choice	
5.2.2(2)P	Characteristic value of self-weight - Additional provisions for buildings		Complementary information
5.2.3(1)-(5)	Characteristic value of self-weight - Additional provisions specific for bridges	Not relevant for building structures	
6.3.1.1 (Table 6.1)	Categories of use	National choice	
6.3.1.2(1)P (Table 6.2)	Imposed loads on floors, balconies and stairs in buildings	National choice	
6.3.1.2(10)	Values of actions - Reduction factor for surface area	National choice	
6.3.1.2(11)	Values of actions - Reduction factor for number of storeys	National choice	
6.3.2.2(1)P (Table 6.4)	Imposed loads on floors due to storage	Recommended values are used	
6.3.3.1	Garages and vehicle traffic areas (excluding bridges) - Categories		Complementary information

6.3.3.2(1) (Table 6.8)	Imposed loads on garages and vehicle traffic areas	Recommended values are used	Complementary information
6.3.4.2(1) (Table 6.10)	Imposed load on roofs of Category H	National choice	
6.4(1) (Table 6.12)	Horizontal loads on partition walls and parapets	National choice	
Annex A	Tables for nominal density of construction materials, and nominal density and angles of repose for stored materials	Annex A is applied	
Annex B	Vehicle barriers and parapets for car parks	Annex B is not applied, see the national choice	Complementary information
Annex C.	Rhythmical and syncronised movement of people	Annex C is applied, cf. clause 2.2(3)	

National choices

2.2(3) Imposed loads - Rhythmic crowd loads
Annex C is applied.

6.3.1.1 (Table 6.1) Characteristic values of imposed loads – Residential, social, commercial and administrative areas - Categories
Imposed loads are divided into the sub-categories shown in Table 6.1

Table 6.1 – Categories of use

Sub-categories	Use	Example
Category A	Areas for domestic and residential activities	A1: Rooms in residential buildings and houses; bedrooms and wards in hospitals; bedrooms in hotels; kitchens and toilets A2: Attics and roof spaces A3: Spaces under roofs A4: Staircases A5: Balconies
B	Office areas	Offices and light industry
C	Areas where people may congregate	C1: Areas with tables C2: Areas with fixed seats C3: Areas without obstacles for moving people C4: Areas with possible physical activities C5: Areas susceptible to large crowds
D	Shopping areas	D1: Areas in general retail shops D2: Areas in large shops and department stores

6.3.1.2 (Table 6.2) Characteristic values of imposed loads – Residential, social, commercial and administrative areas – Values of actions

The characteristic values in Table 6.2 are used

Table 6.2 Imposed loads on floors, balconies and stairs in buildings

Categories	q_k [kN/m^2]	Q_k [kN]
Category A – Domestic and		
residential areas	1,5	2,0
- A1 domestic and residential areas	0,5	0,5
and local access routes	1,0	0,5
- A2 attics	3,0	2,0
- A3 spaces under roofs	2,5	2,0
- A4 staircases		
- A5 balconies	2,5	2,5
Category B – Office areas		
	2,5	3,0
Category C – Areas where people	4,0	3,0
may congregate	5,0	4,0
- C1 with tables		
- C2 with fixed seats		
- C3-C5 without fixed seats	4,0	4,0
	5,0	7,0
Category D – Shopping areas		
- D1 areas in general retail shops	3,0	3,0
- D2 large shops and department	5,0	4,0
stores	5,0	4,0
-		
Category B-C1 local access routes 1)		
Category B-C1 common access routes 1)		
Category C2-D access routes		
NOTE 1) Common access routes include staircases and stairwells of the same height as the building as well as halls leading to stairs. Other access routes are considered to be local access routes. A ψ-value is assigned to the load, corresponding to the maximum ψ-value of the premises served by the access route.		

NOTE 1 NA:
Roof terraces and balconies are assigned to the same category as the adjacent premises. However, loads corresponding to category A5 shall as a minimum be applied.
The imposed loads for roof terraces and balconies are assumed to include any simultaneous contri-

butions from snow loads. Snow loads including drifting may result in increased loads; in this case the imposed load is disregarded.

NOTE 2 NA:
Archive areas in office buildings are to be assigned to category D2.

6.3.1.2 (10) Characteristic values of imposed loads – Residential, social, commercial and administrative areas – Values of actions – Reduction factor for surface area
The reduction factor for surface area is not applied.

6.3.1.2 (11) Characteristic values of imposed loads – Residential, social, commercial and administrative areas – Values of actions – Reduction factor for number of storeys
The following reduction factor for the number of storeys is applied

$$\alpha_n = \frac{1+(n-1)\psi_0}{n}$$

where

n is the number of storeys (n>1) above the loaded structural element from the same category

ψ_0 is the load reduction factor, see DS/EN 1990.

6.3.2.2(1)P (Table 6.4) Characteristic values of imposed loads – Areas for storage and industrial activities – Values of actions
The characteristic values in Table 6.4 are used.

Table 6.4 Imposed loads on floors due to storage

Categories	q_k [kN/m^2]	Q_k [kN]
Category E – Industrial areas	7,5	7,0

6.3.3.2(1) (Table 6.8) Garages and vehicle traffic areas (excluding bridges) – Values of actions
The characteristic values in Table 6.8 are applied.

Table 6.8 Imposed loads on garages and vehicle traffic areas

Categories of traffic areas	q_k [kN/m^2]	Q_k [kN]
Category F Gross vehicle weight: ≤ 30 kN	2,5	20
Category G 30 kN < gross vehicle weight = 160 kN	5,0	90

6.3.4.2(1) (Table 6.10) Characteristic values of imposed loads – Roofs – Values of actions
The characteristic values in Table 6.10 are applied; however, the characteristic values are taken as 0 in combination with snow loads.

Table 6.10 Imposed loads on roofs of category H

Roof	q_k [kN/m^2]	Q_k [kN]
Category H	0,0	1,5

6.4(1) (Table 6.12) Horizontal loads on parapets and partition walls acting as barriers
The characteristic values in Table 6.12 are used.

Table 6.12 - Horizontal loads on partition walls and parapets

Loaded areas	q_k [kN/m]
Category A	0,5
Categories B and C1	0,5
Categories C2 to C4 and D	1,0
Category C5	3,0
Category E	2,0
Category F	See Annex B
Category G	See Annex B

NOTE 7 NA:
The horizontal load is to be considered to act at the same time as the vertical load, if it is unfavourable. In this case the same ψ value is to be applied for the horizontal load and for the vertical load. The horizontal load is assumed not to act at the same time as wind loads.

Annex A: Tables for nominal density of construction materials, and nominal density and angles of repose for stored materials
Annex A is applied.

Annex B: Vehicle barriers and parapets for car parks
Annex B is not applied; reference is made to DS/EN 1991-1-7 and the associated National Annex.

Annex C: (normative) Rhythmical and syncronised movement of people

C.1 Scope and field of application

(1) The imposed loads specified in DS/EN 1991-1-1 include moderate dynamic actions and will be sufficient for most structures without additional dynamic verifications. However, they do not include the special load conditions caused by rhythmical and synchronised movement of people.

(2) Rhythmic crowd loads include the load induced by coordinated jumping and stamping, e.g. by spectators on grandstands at sporting events and rock concerts, or by people performing physical exercises in fitness centres. The rules can also be applied in connection with the designing of sports halls and places of public assembly.

(3) Rhythmic crowd loads will be especially important if the movements of the individuals (dancing, jumping, rhythmical stamping, aerobics, etc.) are synchronised. In practice, this only occurs in connection with a distinct musical beat e.g. at rock concerts or aerobics, and it may occur at certain sporting events. The dynamic load is therefore related to the musical beat or dance frequency and it is periodic. These movements of people can generate both vertical and horizontal loads, and the loads are determined by adding the effects from the movements of the individuals, taking account at the same time of the reduced correlation between the movements. If the syncronised movements produce periodic load effects at the natural frequency of the structure, resonance occurs and this can lead to significant magnification of the structural response.

(4)P The load combination factors are taken as $\psi_0 = 0$, $\psi_1 = 0$ and $\psi_2 = 0$. Rhythmic crowd loads shall be taken into account as a free action.

C.2 Load model

(1) Rhythmic crowd loads are modelled by harmonic load components at the movement frequency of the group of people and at frequencies equal to jn_p ($j = 1, 2, 3, ...$). For the structures considered in C.1(2), load contributions where $j > 3$ are disregarded. The rhythmic crowd loads in the vertical direction, q_L, and in the horizontal direction, q_V, are therefore determined by:

$$q_L(t) = F_p[1 + \sum_{j=1,2,3} \alpha_j K_j \sin(2\pi j n_p t + \varphi_j) \qquad \text{(C1)}$$

$$q_V(t) = F_p \sum_{j=1,2,3} \beta_j K_j \sin(2\pi j n_V t + \Psi_j) \qquad n_V = \frac{1}{2} n_p \qquad \text{(C2)}$$

where

F_P is the mean static crowd load per m² horizontal projection area. The average weight of each person can normally be estimated to be 75 kg;

α_j is the amplitude factor for the *j*th harmonic load component in the vertical direction;

β_j is the amplitude factor for the *j*th harmonic load component in the horizontal direction;

K_j is the size reduction factor for the *j*th harmonic load component. K_j takes account of the reduced correlation between the movements of the individuals. When the deflections due to crowd loads have the same sign all over the structure, it is on the safe side to use $K_j = 1$;

n_p is the movement frequency of the group of people;

t is the time

φ_j is the phase shift for the *j*th harmonic load component in the vertical direction

ψ_j is the phase shift for the *j*th harmonic load component in the horizontal direction.

NOTE The dimensioning of the structure is based on the most unfavourable values for the phase shifts φ_j and ψ_j. Therefore, these phase shifts are not explicitly included in the expressions given for determining the equivalent static load and acceleration of the structure in C.4 and C.5, respectively.

(2) The load model in (1) is a simplified description of the actual conditions. As an example, correlations between the different phase shifts φ_j and ψ_j, and the fact that the movements of people do not all occur at a single frequency only but at several frequencies around the movement frequency n_p, have been disregarded.

(3)P The crowd load q_V can act in all horizontal directions, and it shall be assumed to act at the same time as the vertical load q_L.

(4) The size reduction factor depends on the conditions governing the rhythmic activity. For the *j*th harmonic load component, it can approximately be taken as:

$$K_j = \sqrt{\rho_j + (1 - \rho_j)\frac{1}{n_e}} \tag{C3}$$

$$n_e = n\frac{\left(\frac{1}{n}\sum_{i=1}^{n}\gamma_i\right)^2}{\frac{1}{n}\sum_{i}^{n}\gamma_i^2} \tag{C4}$$

where

ρ_j is the correlation coefficient for the jth harmonic load component, see Table C.1

n is the number of people $(n \geq 1)$

n_e is the effective number of people

γ_i is the influence coefficient for the response due to the load from person no. i' on the structure.

K_j is equal to 1 for $n = 1$.
It is assumed that γ_ii has the same sign for all n people. For a structure with a constant influence number for all people, n_e=n will apply. For a simply supported beam with a uniformly distributed static load, n_e/n = ¾ applies for the bending moments of the beam and support reactions due to static loads, and $n_e/n = 8/\pi^2$ applies for load components in resonance with the structure. Resonance occurs for load component no. j, when the frequency of the load component jn_P is equal to the natural frequency of the structure n_1.

(5) The characteristic rhythmic crowd load may be determined using the parameter values given in Table C.1. The mean static crowd load, F_P, shall always be evaluated in the situation in question, and the limit state considered shall be included in this evaluation. β_j is assumed to be 10% of α_j.

Table C.1 - Parameters for determining the characteristic rhythmic crowd load

Activity	F_P [kN/m^2]	n_p [Hz]	α_1	α_2	α_3	ρ_1	ρ_2	ρ_3
Possibility to move about freely, e.g. in fitness centres and on grandstands with standing room	0,5-4,0	0,5-3	1,6	1,0	0,2	1,0	0,3	0,03
Reduced possibility to move about, e.g. on grandstands with seats	0,5-4,0	0,5-3	0,4	0,25	0,05	1,0	0,1	0,01
Walking. People do not walk in step	To be evaluated	1,6-2,4	0,4	0,1	0,06	0	0	0
NOTE In ultimate limit states the value of F_P will often be taken as greater than in serviceability limit states.								

(6)P Grandstands are often subject to horisontal movements caused by rhythmic crowd loads. The amplitude of the characteristic horisontal rhythmic crowd load shall be taken as at least 10% of the total characteristic imposed load of Category C. The horisontal load acts in the same places as the rhythmic crowd load.

C.3 Calculation of load effect

(1) The load model referred to in C.2(1) defines the time history of the load. The effects of this load on the structure can be calculated in many ways depending on the complexity of the structure and the degree of accuracy required.

(2) For structures where the following conditions are met:

- the deflections from static crowd loads have the same sign for the entire structure;
- only vibration contributions from a single vibration mode are taken into account;
- the vibration mode considered has essentially vertical components only, and these have the same sign over the entire structure;
- the vibration mode considered is not linked to other vibration modes;
- the structure has a linear-elastic behaviour;
- 3 load harmonics are of importance,

an equivalent static load and the acceleration of the structure can be determined as described below.

C.4 Equivalent static load

(1) The maximum effect of the vertical rhythmic crowd load can be determined as the effect of an equivalent static load, F_s, given as:

$$F_s = (1 + k_F)F_P \qquad \text{(C5)}$$

where

k_F is the load response factor determined in (3)

F_P is the mean static crowd load, see Table C.1.

(2) The response from the j'th load component depends on the frequency response factor of the structure, H_j, defined as follows:

$$H_j = \frac{1}{\sqrt{\left(1 - \left(\frac{jn_P}{n_1}\right)^2\right)^2 + \left(\frac{\delta_s + \delta_P jn_P}{\pi n_1}\right)^2}} \qquad \text{(C6)}$$

where

n_P is the movement frequency of the group of people, see Table C.1

n_1 is the natural frequency of the structure;

δ_s is the structural damping expressed by the logarithmic decrement;

δ_P is a damping parameter which takes account of the fact that the crowd movements do not occur at one frequency only. It is on the safe side to use $\delta_P = 0{,}02$.

NOTE For rough estimates of the damping of concrete structures without prestress, composite structures and timber structures $\delta_s \approx 0{,}1$, and for prestressed concrete structures and steel structures $\delta_s \approx 0{,}05$.

(3) The load response factor k_F may be calculated as follows:

$$k_F = a \cdot \sqrt{\sum_{j=1}^{3} (\alpha_j K_j H_j)^2} \tag{C7}$$

where

a is the response distribution factor depending on the number of dominant load harmonics. When a single load harmonic component dominates the response, $a=1$ is assumed, and in other situations $a=1{,}5$ will be representative;

α_j is the amplitude factor for the jth harmonic load component, see Table C.1;

K_j is the size reduction factor, see C.2 (4);

H_j is the structural frequency response factor, see (2).

The load response factor, k_F, is to be determined for the maximum frequency of movement possible as specified in Table C.1 and for frequencies of movement where one of the load harmonic components is equal to the natural frequency of the structure ($jn_p = n_1$, j=1,2 or 3).

C.5 Acceleration of the structure

(1) The deviation σ_a of the acceleration of the structure induced by the vertical dynamic load can be determined using the expression:

$$\sigma_a = k_a (2\pi n_p)^2 u_p \tag{C8}$$

where

k_a is the acceleration response factor determined in (2)

n_P is the movement frequency of the group of people, in Hz

u_P is the static deflection from the mean static crowd load, F_P.

(2) The acceleration response factor, k_a, can be determined using the expression:

$$k_a = \sqrt{\frac{1}{2} \sum_{j=1}^{3} (j^2 \alpha_j K_j H_j)^2} \tag{C9}$$

where

α_j is the amplitude factor for the jth harmonic load component, see Table C.1;

K_j is the size reduction factor, see C.2 (4);

H_j is the structural frequency response factor, see C.4(2).

The acceleration response factor, k_a, is to be determined for the maximum frequency of movement possible as specified in Table C.1 and for frequencies of movement where one of the load harmonic components is equal to the natural frequency of the structure ($jn_p = n_1$, j=1,2 or 3).

Complementary (non-contradictory) information

1.4.7 Moveable partitions

Movable partitions are those which can be re-built at another place without major measures.

2.1(2) Classification of actions – Self-weight

The existing note is supplemented by a new note:

Where the load cannot be assumed to be present during the lifetime of the building, the lower characteristic value of the load is taken as 0. This may apply e.g. to non-structural elements and fixed services specified in 5.1 (3)-(4).

5.2.2(2)P Characteristic value of self-weight - Additional provisions for buildings

Loads induced by light partitions may be taken into account as self-weight in the form of an equivalent uniformly distributed vertical load, see 2.1.

Light partitions are non-structural walls which fulfil the following two conditions:

- the total load on the wall per m² of the wall surface does not exceed 1,5 kN/m²;
- the total load on the wall per m of the wall length does not exceed 4,0 kN/m.

The characteristic value of the equivalent uniformly distributed load for light partitions shall be taken into account by the upper characteristic value and the lower characteristic value, respectively. As the upper characteristic value the largest of the following three values shall as a minimum be used:

- 0,5 kN/m²;
- the load of the walls per m^2 of the wall surface;
- the load of the weight of all light partitions on the considered floor area, divided by the floor area.

For the lower characteristic value, see 2.1(2).

The load due to heavier non-structural partitions is taken into account as self-weight on the basis of their actual locations and the structural form of the floor.

6.3.3.1(1) Characteristic values of imposed loads - Garages and vehicle traffic areas (excluding bridges) – Categories

Denmark often applies a different value than that specified for category F in Table 6.7 as the upper value for standard vehicles and small lorries/commercial vehicles is 3 500 kg, i.e. approximately 35 kN.

6.3.3.2(1) Characteristic values of imposed loads - Garages and vehicle traffic areas (excluding bridges) – Values of actions

Attention is drawn to the fact (as stated in 6.3.3.1(P)) that a different limit for small vehicles is applied in Denmark. If the garage/vehicle traffic area is designed for 30kN (category F), conspicuous signs and other physical barriers ensure that ordinary vehicles of e.g. 3,5 t do not enter the garage/vehicle traffic area.
If the garage is designed for vehicles up to 35kN, a uniformly distributed load of $q_k = 3{,}0$ kN/m^2 and a concentrated load of $Q_k = 20$ kN are applied.

Annex B: Vehicle barriers and parapets for car parks
The determination of the impact forces for vehicle barriers and parapets positioned crosswise to long ramps intended for traffic going down should be based on project specific evaluations and analyses of traffic conditions, the layout and geometry of the structure, and the consequences of failure.